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Giobbi

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(54) **SECURE ELEMENT AS A DIGITAL POCKET**

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(22) Filed: **May 10, 2014**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**

H04L 9/32	(2006.01)
G06F 21/44	(2013.01)
G06F 21/34	(2013.01)
H04L 29/06	(2006.01)
H04W 12/08	(2009.01)

(52) **U.S. Cl.**

CPC ***G06F 21/44*** (2013.01); ***G06F 21/34*** (2013.01); ***H04L 63/0861*** (2013.01); ***H04W 12/08*** (2013.01)

(58) **Field of Classification Search**

CPC .. H04W 12/06; H04W 12/08; H04L 63/0853; H04L 63/0861; H04L 63/101; G06F 21/32; G06K 9/00275; G06K 9/00281; G06K 9/00302; G06K 9/00382

USPC 713/168, 182, 185, 186, 193; 726/2-5, 726/9; 380/270; 382/115-118, 124

See application file for complete search history.

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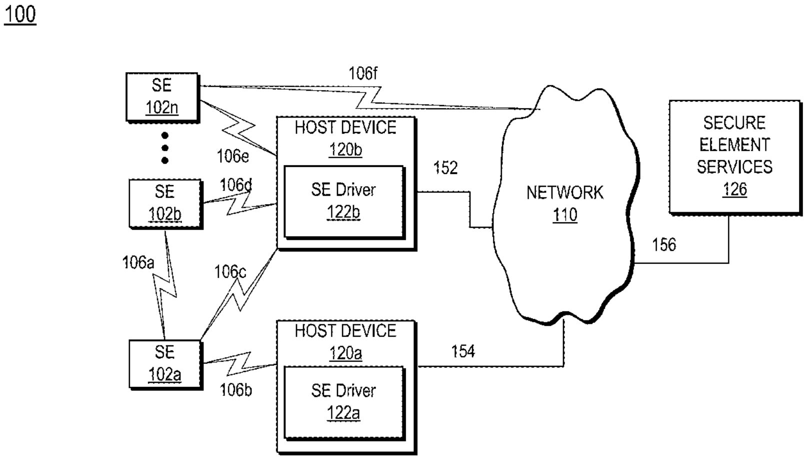
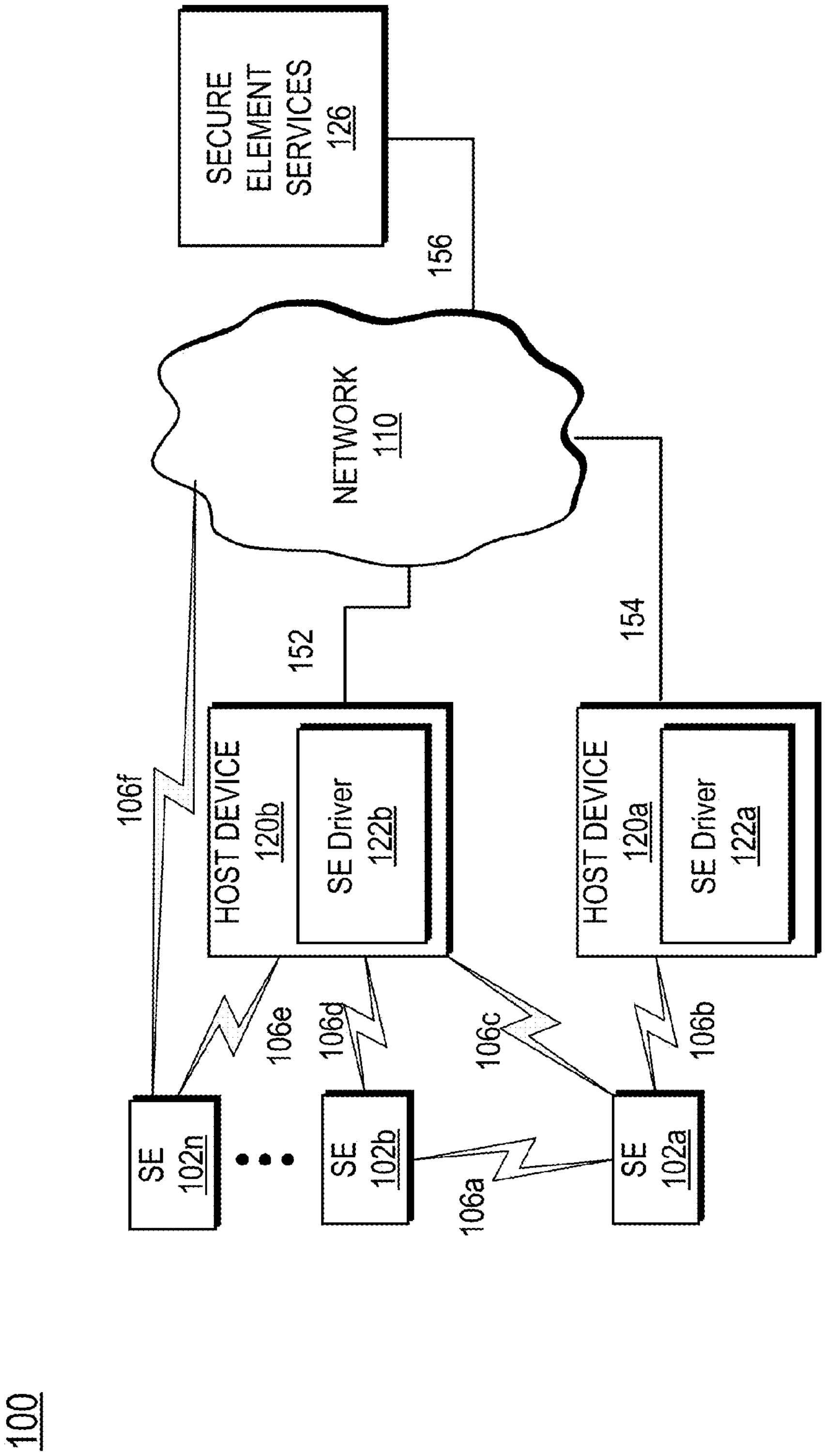
(57) **ABSTRACT**

The disclosure includes a system and method in which one or more virtual resources are presented to a secure element; and the one or more virtual resources are mapped to available resources based on a model architecture for the secure element in order to provide hardware abstraction, the available physical resources varying based on the model architecture and an associated host device, the virtual resources allowing consistent interaction with the virtual resources regardless of variation in the physical resources available and their location. The hardware abstraction increases the versatility of the secure element and may contribute to the secure element's functionality. The secure element providing functionality to replace most items carried in an individual's pockets, e.g., logical and physical keys, a thumb drive, identification, credit and debit cards, etc.

19 Claims, 16 Drawing Sheets

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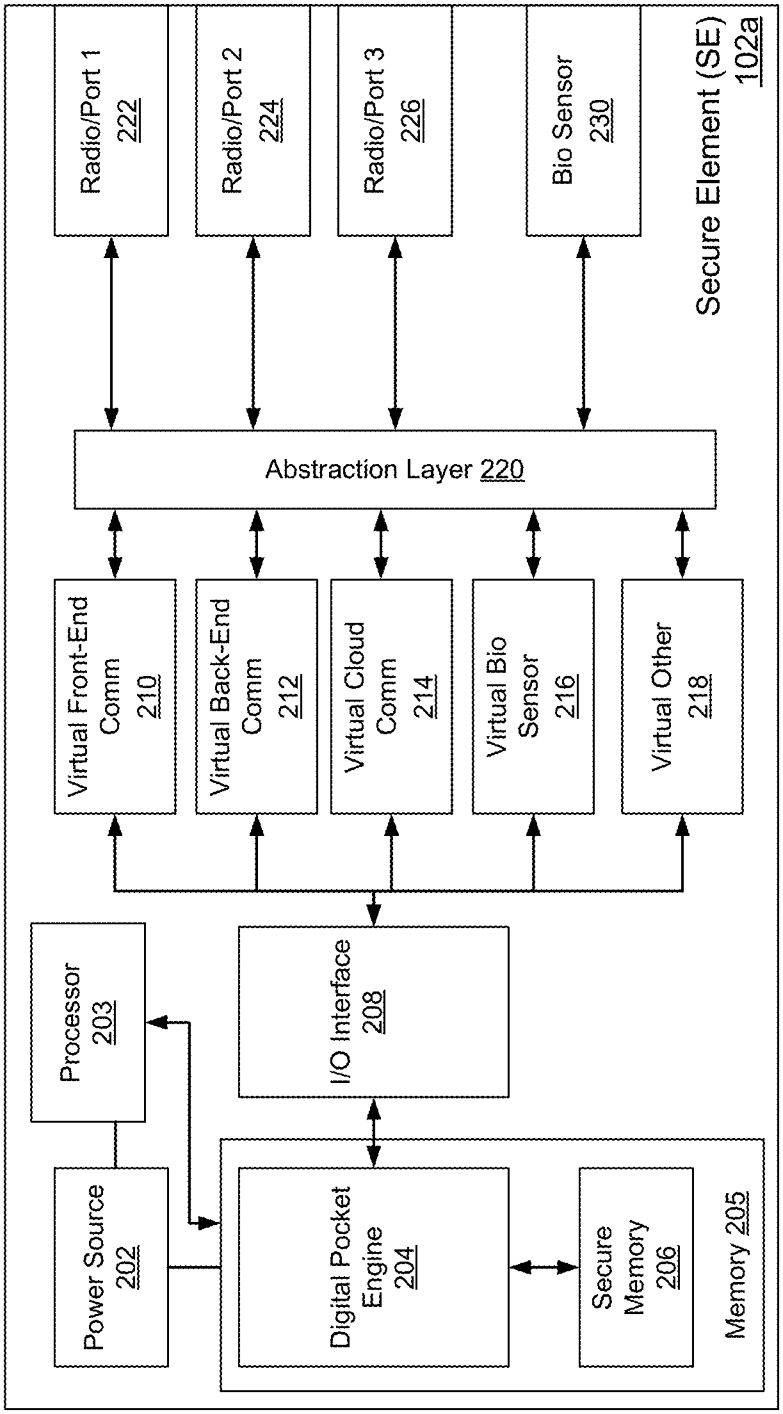
SE 102n
SE 102b
SE 102a
106a
106b
106c
106d
106e
106f
HOST DEVICE 120b
SE Driver 122b
HOST DEVICE 120a
SE Driver 122a
152
154
156
NETWORK 110
SECURE ELEMENT SERVICES 126

FIG. 1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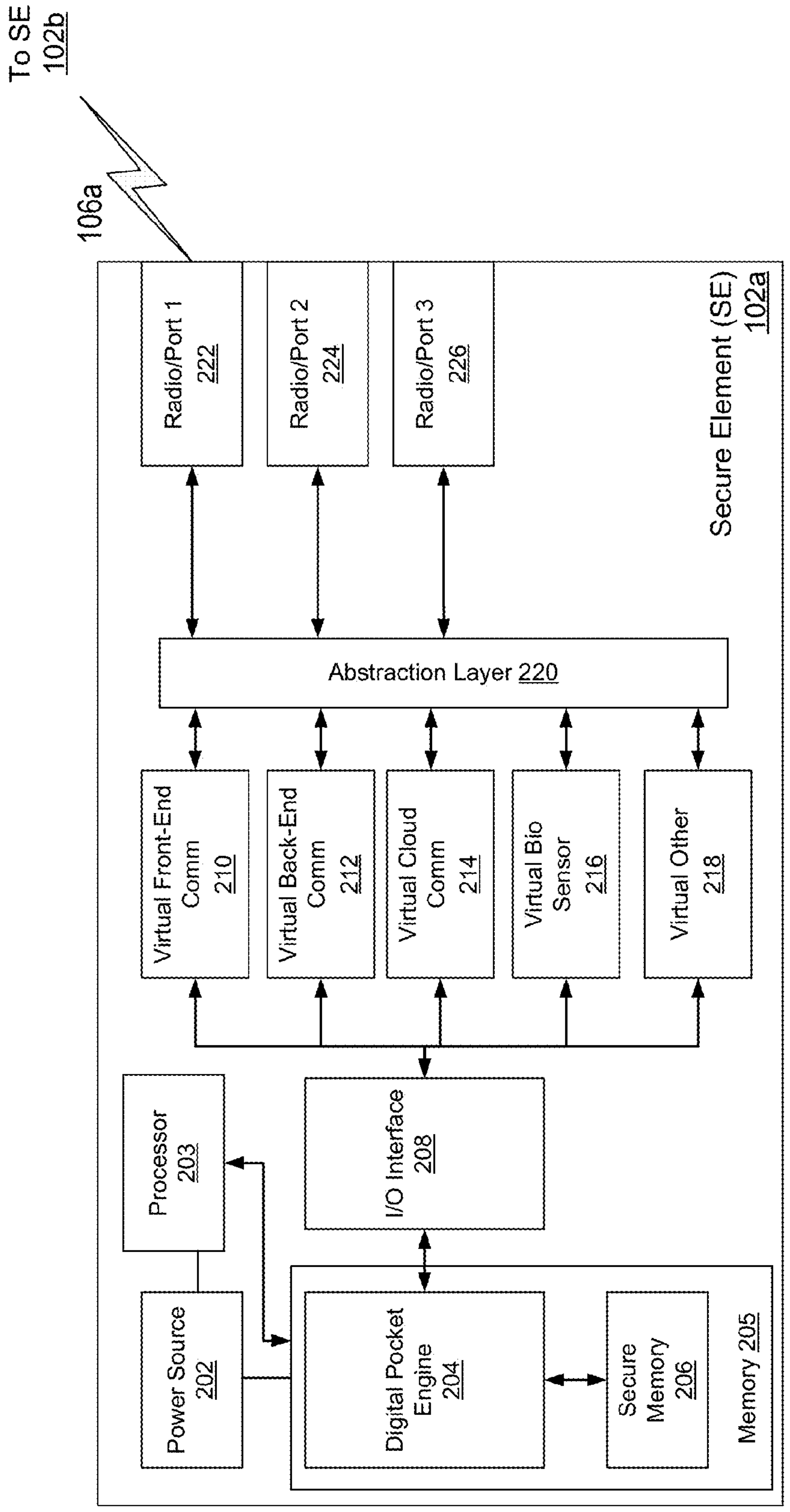
Radio/Port 1 222
Radio/Port 2 224
Radio/Port 3 226
Bio Sensor 230
Abstraction Layer 220
Virtual Front-End Comm 210
Virtual Back-End Comm 212
Virtual Cloud Comm 214
Virtual Bio Sensor 216
Virtual Other 218
Processor 203
I/O Interface 208
Power Source 202
Digital Pocket Engine 204
Secure Memory 206
Memory 205

FIG. 2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106a
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Radio/Port 1 222
Radio/Port 2 224
Radio/Port 3 226
Abstraction Layer 220
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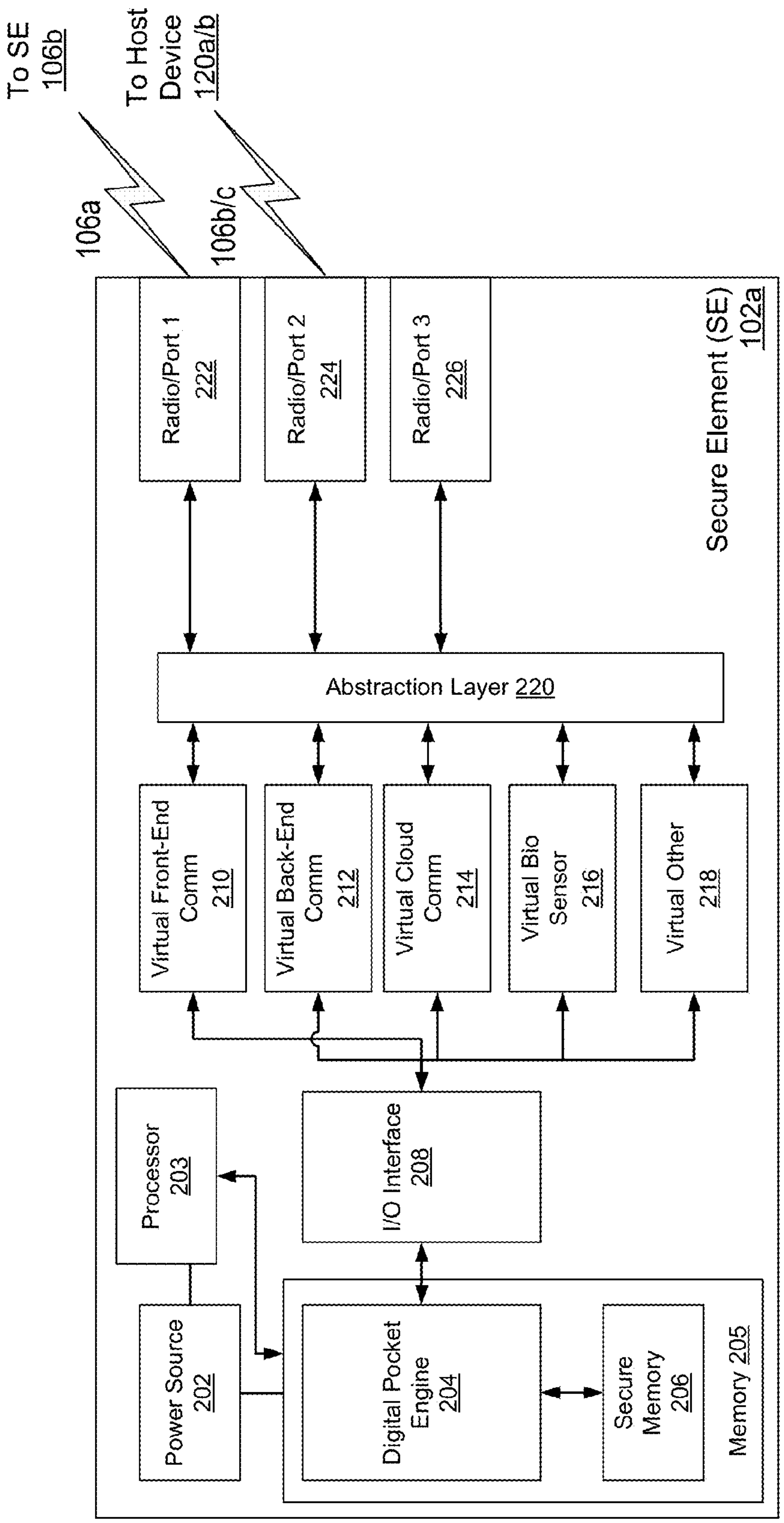
Virtual Back-End Comm 212
Virtual Cloud Comm 214
Virtual Bio Sensor 216
Virtual Other 218
Processor 203
I/O Interface 208
Power Source 202
Digital Pocket Engine 204
Secure Memory 206
Memory 205

FIG. 3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To Host Device 120a/b
106a
106b/c
Radio/Port 1 222
Radio/Port 2 224
Radio/Port 3 226
Secure Element (SE) 102a
Abstraction Layer 220
Virtual Front-End Comm 210
Virtual Back-End Comm 212
Virtual Cloud Comm 214
Virtual Bio Sensor 216
Virtual Other 218
Processor 203
I/O Interface 208
Power Source 202
Digital Pocket Engine 204
Secure Memory 206
Memory 205

FIG. 4

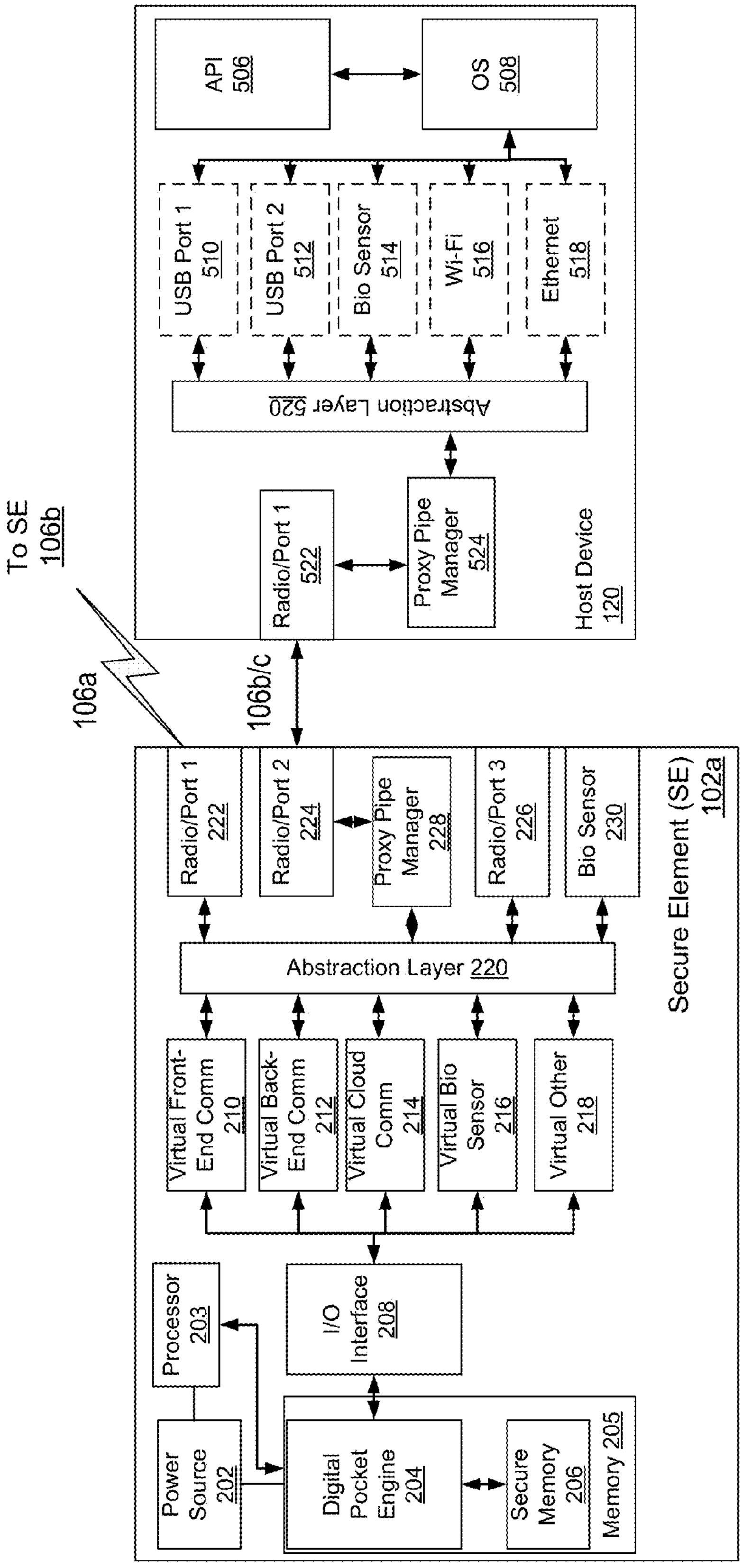
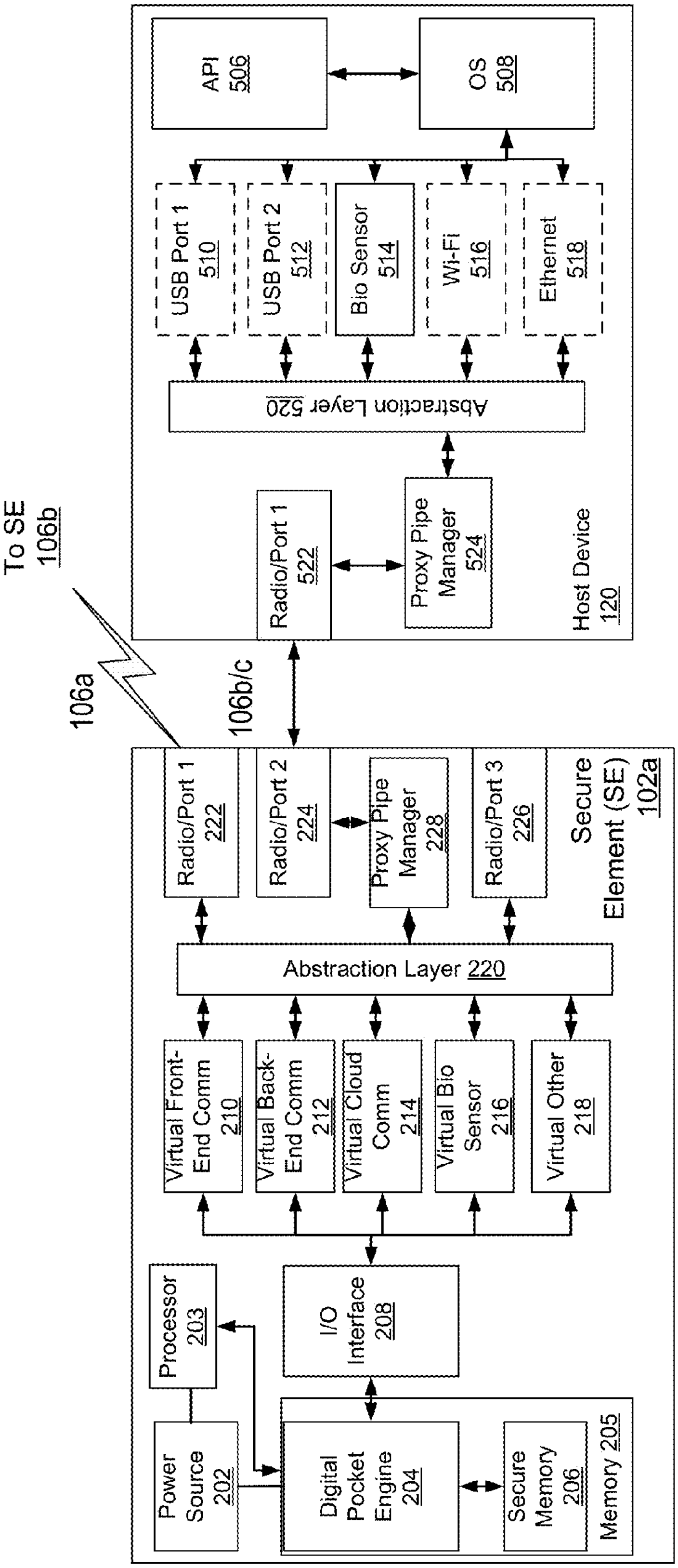

API 506
OS 508
USB Port 1 510
USB Port 2 512
Bio Sensor 514
Wi-Fi 516
Ethernet 518
Abstraction Layer 520
Radio/Port 1 522
Proxy Pipe Manager 524
Host Device 120
To SE 106b
106a
106b/c
Radio/Port 1 222
Radio/Port 2 224
Proxy Pipe Manager 228
Radio/Port 3 226
Bio Sensor 230
Secure Element (SE) 102a
Abstraction Layer 220
Virtual Front-End Comm 210
Virtual Back-End Comm 212
Virtual Cloud Comm 214
Virtual Bio Sensor 216
Virtual Other 218
Processor 203
I/O Interface 208
Power Source 202
Digital Pocket Engine 204
Secure Memory 206
Memory 205

FIG. 5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106a
106b/c
API 506
OS 508
USB Port 1 510
USB Port 2 512
Bio Sensor 514
Wi-Fi 516
Ethernet 518
Abstraction Layer 520
Radio/Port 1 522
Proxy Pipe Manager 524
Host Device 120
Radio/Port 1 222
Radio/Port 2 224
Proxy Pipe Manager 228
Radio/Port 3 226
Secure Element (SE) 102a
Abstraction Layer 220
Virtual Front-End Comm 210
Virtual Back-End Comm 212
Virtual Cloud Comm 214
Virtual Bio Sensor 216
Virtual Other 218
Processor 203
I/O Interface 208
Power Source 202
Digital Pocket Engine 204
Secure Memory 206
Memory 205

FIG. 6

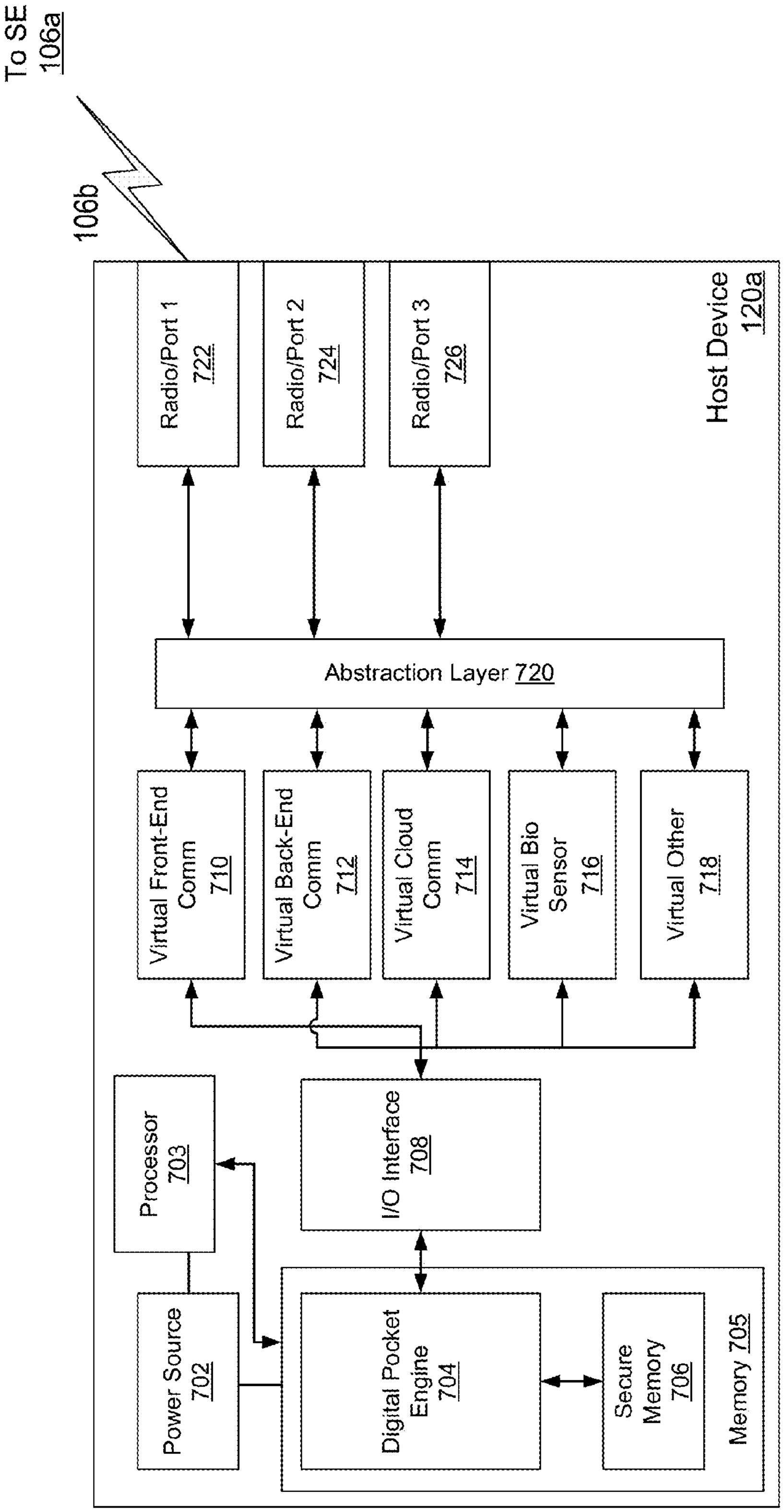
To SE
106a
106b
Host Device
120a
Radio/Port 1
722
Radio/Port 2
724
Radio/Port 3
726
Abstraction Layer 720
Virtual Front-End Comm
710
Virtual Back-End Comm
712
Virtual Cloud Comm
714
Virtual Bio Sensor
716
Virtual Other
718
Processor
703
I/O Interface
708
Power Source
702
Digital Pocket Engine
704
Secure Memory
706
Memory 705

FIG. 7

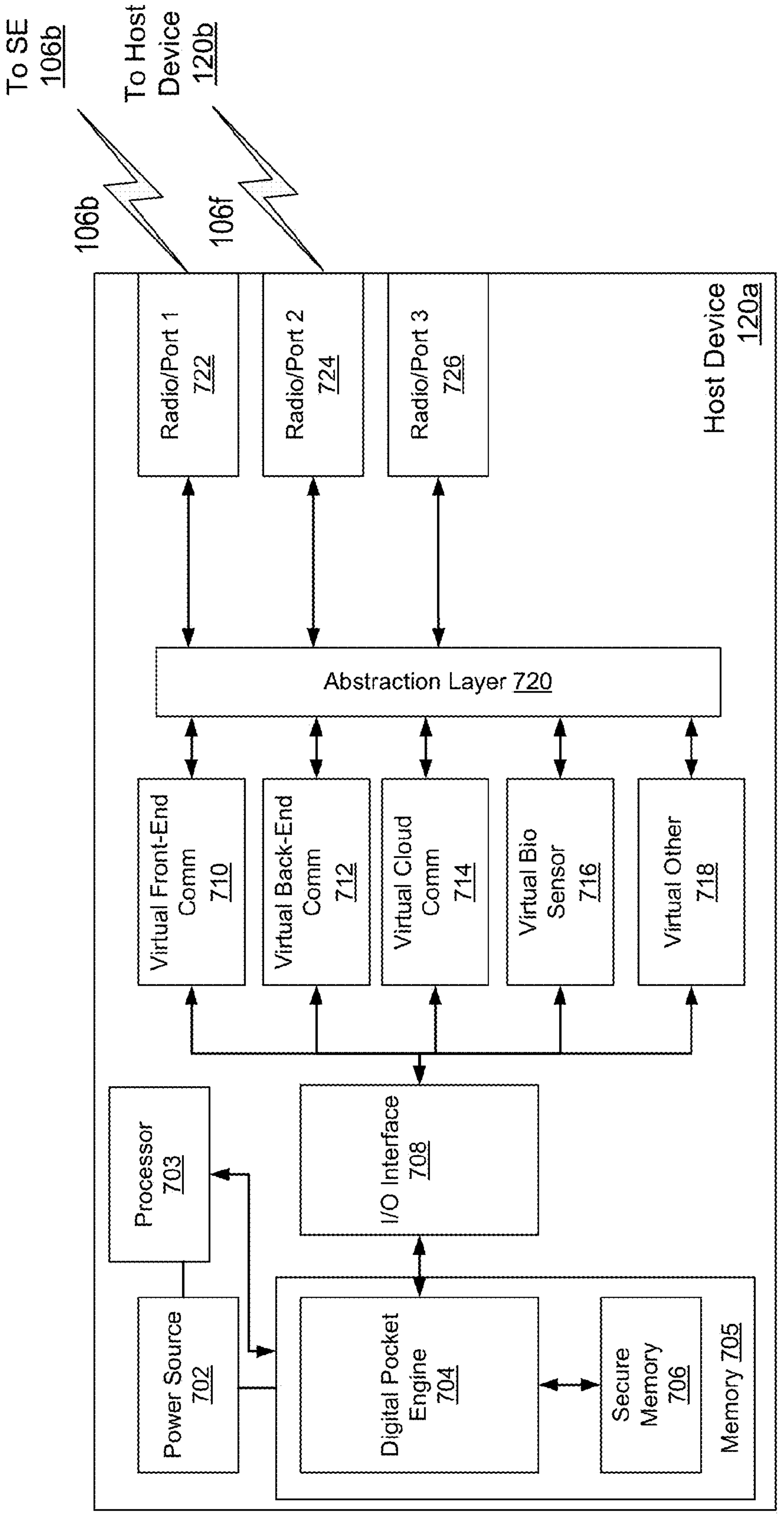
To SE 106b
To Host Device 120b
106b
106f
Radio/Port 1 722
Radio/Port 2 724
Radio/Port 3 726
Host Device 120a
Abstraction Layer 720
Virtual Front-End Comm 710
Virtual Back-End Comm 712
Virtual Cloud Comm 714
Virtual Bio Sensor 716
Virtual Other 718
Processor 703
I/O Interface 708
Power Source 702
Digital Pocket Engine 704
Secure Memory 706
Memory 705

FIG. 8

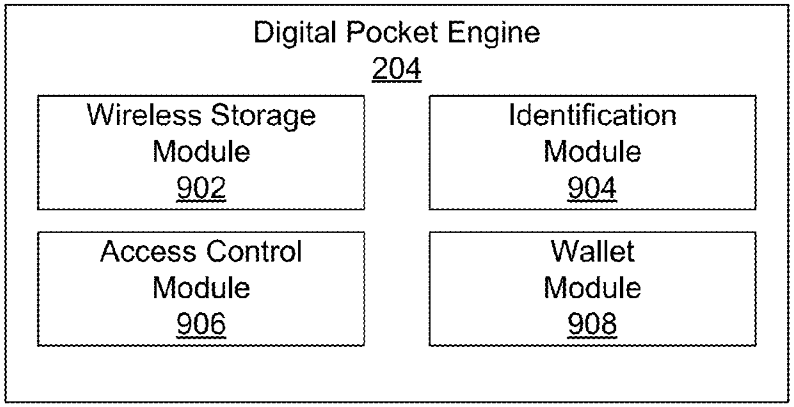
Digital Pocket Engine
204
Wireless Storage Module
902
Identification Module
904
Access Control Module
906
Wallet Module
908

FIG. 9

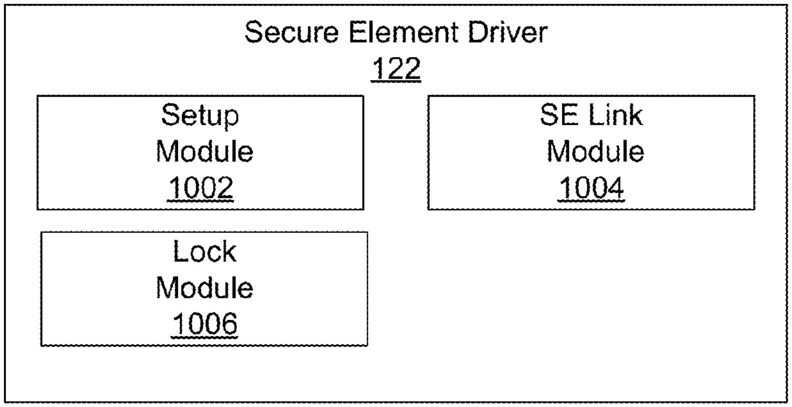
Secure Element Driver
122
Setup Module
1002
SE Link Module
1004
Lock Module
1006

FIG. 10

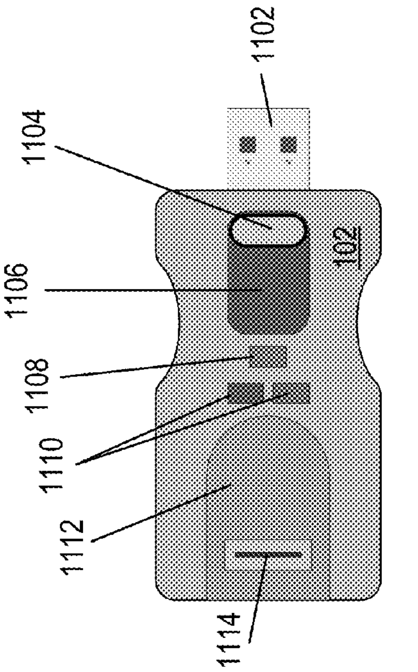

FIG. 11A

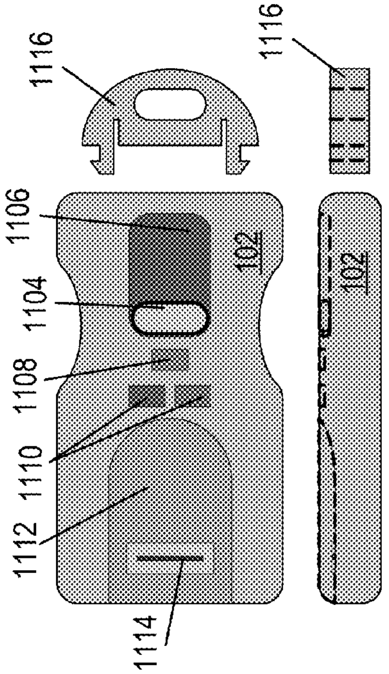

FIG. 11B

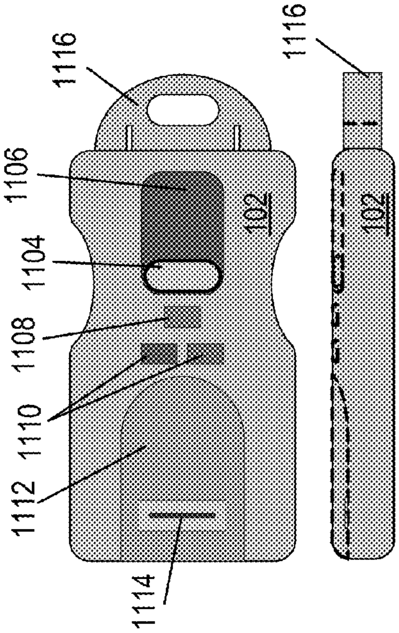

FIG. 11C

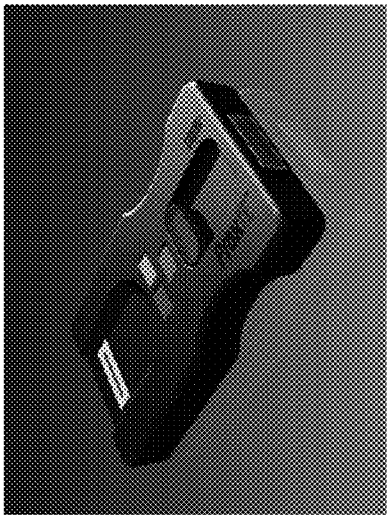

FIG. 12A

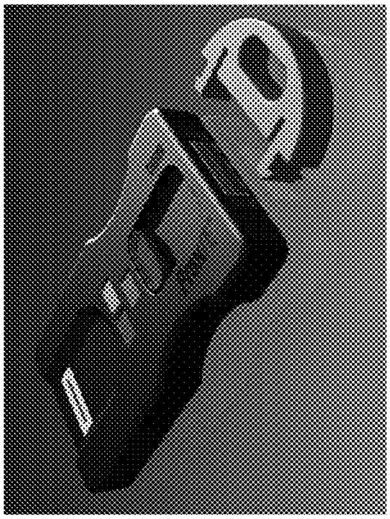

FIG. 12B

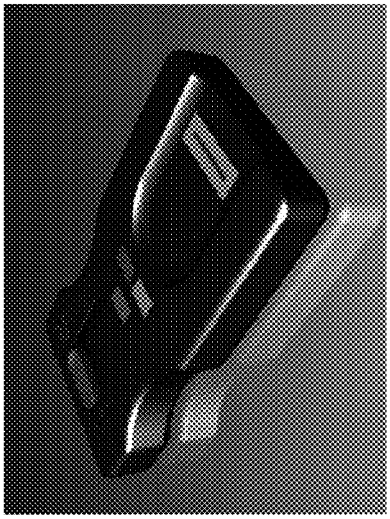

FIG. 12C

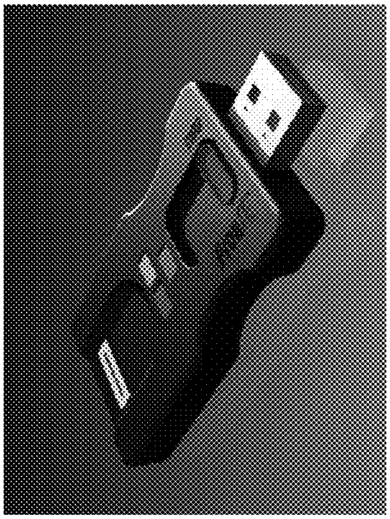

FIG. 12D

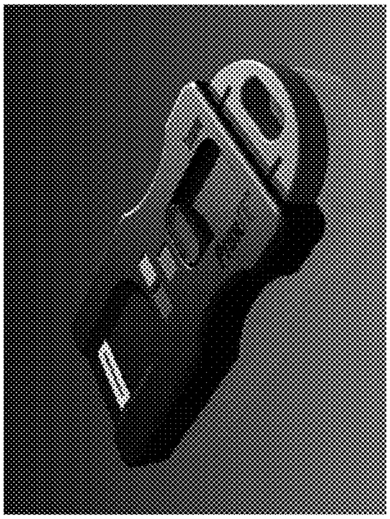

FIG. 12E

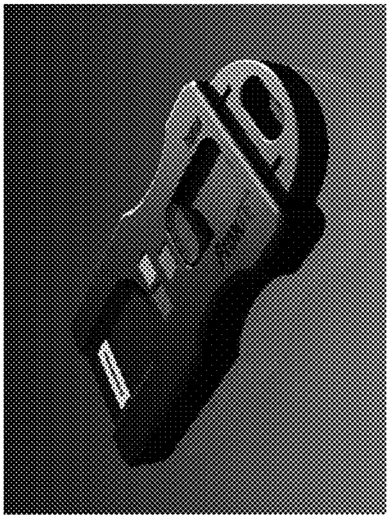

FIG. 12F

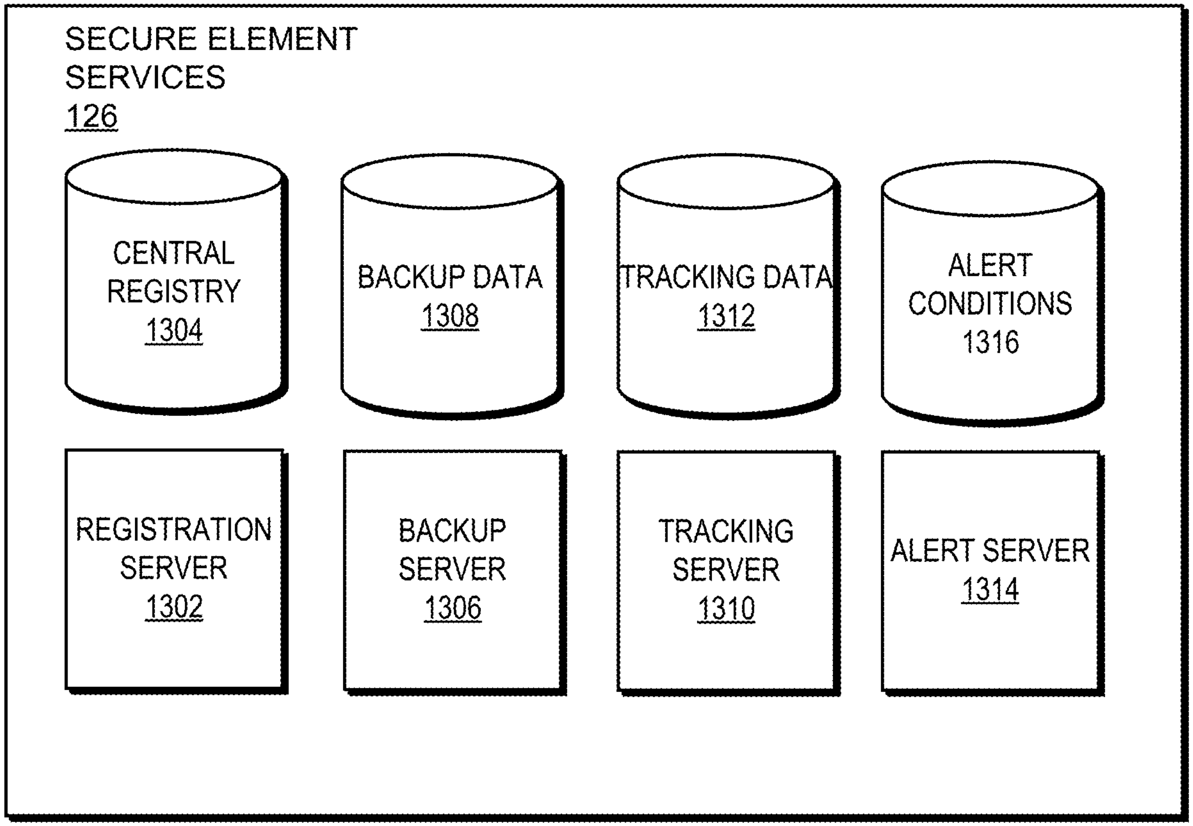
SECURE ELEMENT
SERVICES
126
CENTRAL
REGISTRY
1304
BACKUP DATA
1308
TRACKING DATA
1312
ALERT
CONDITIONS
1316
REGISTRATION
SERVER
1302
BACKUP
SERVER
1306
TRACKING
SERVER
1310
ALERT SERVER
1314

FIG. 13

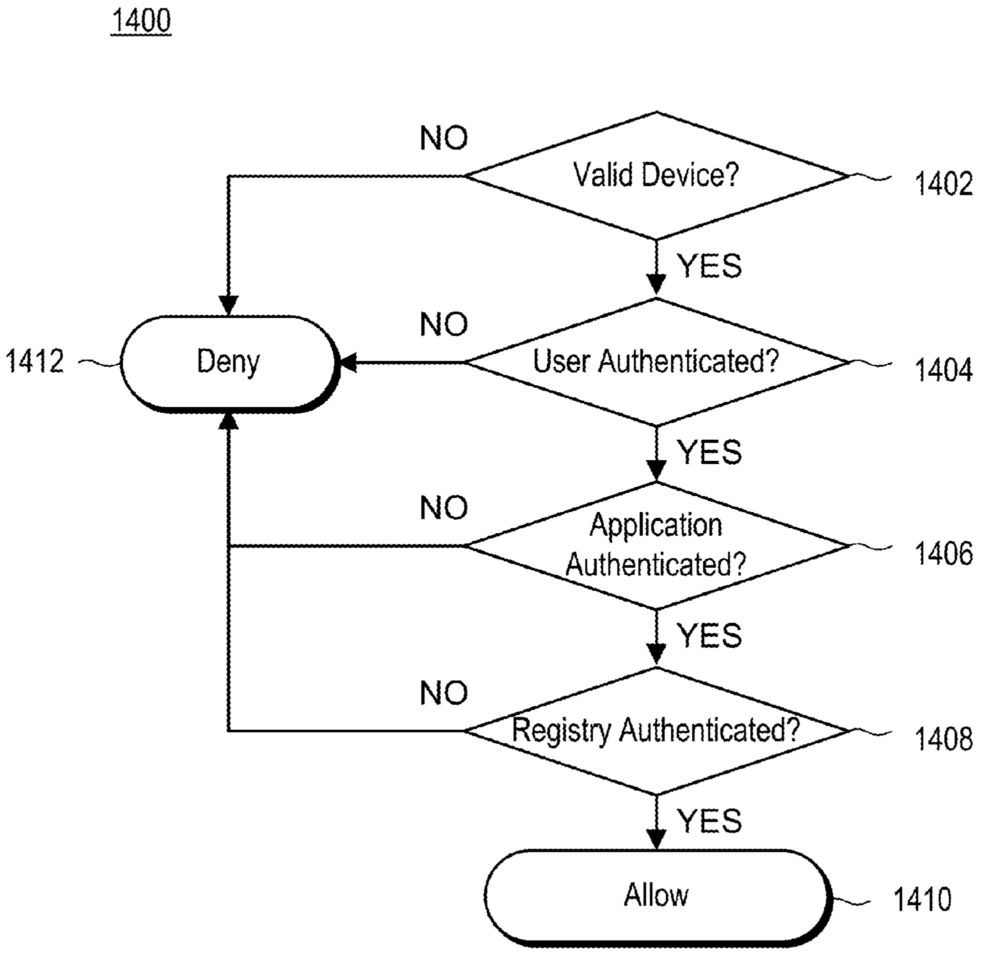
1400
NO
Valid Device?
1402
YES
NO
1412
Deny
User Authenticated?
1404
YES
NO
Application Authenticated?
1406
YES
NO
Registry Authenticated?
1408
YES
Allow
1410

Figure 14

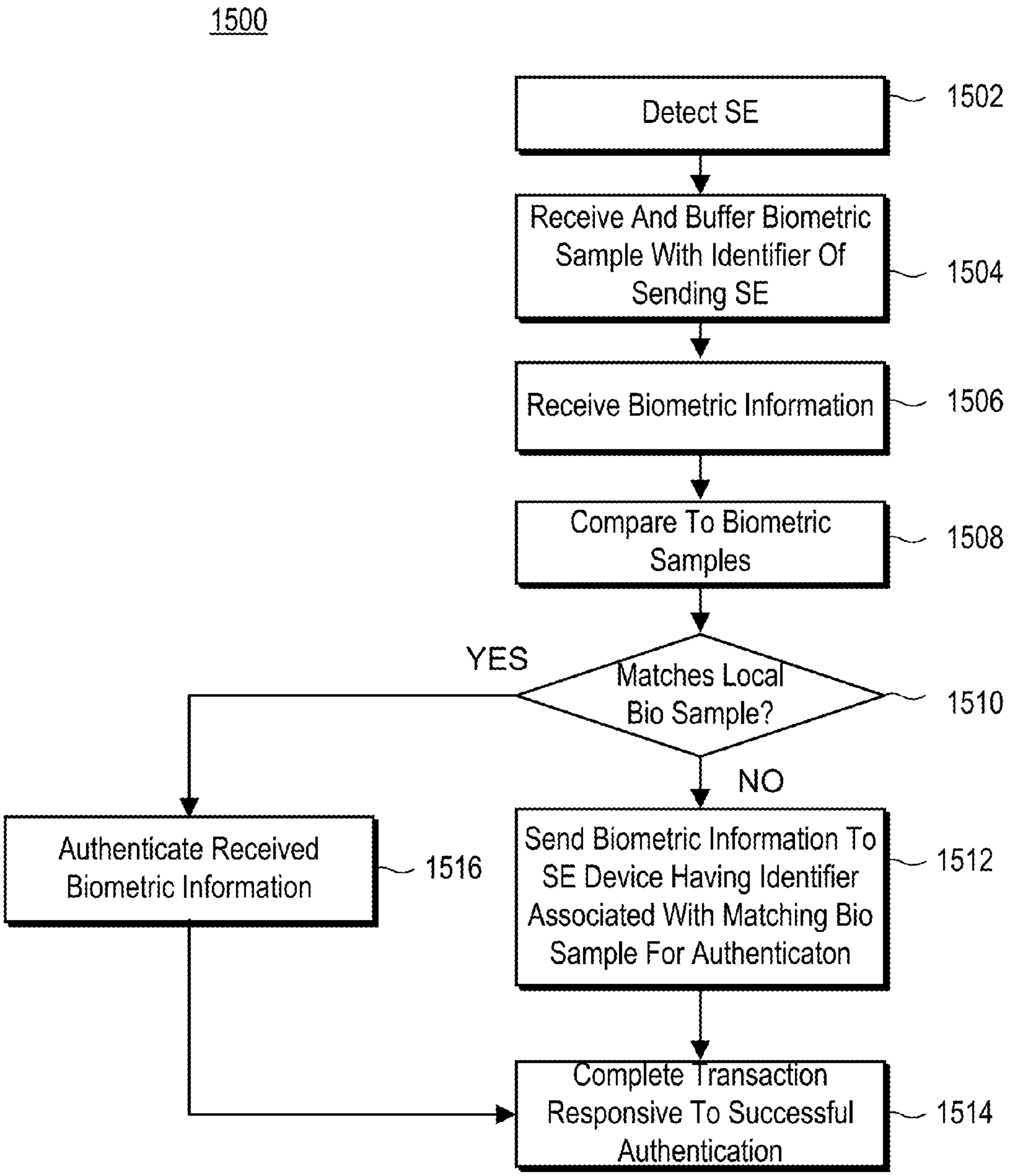
1500
Detect SE
1502
Receive And Buffer Biometric Sample With Identifier Of Sending SE
1504
Receive Biometric Information
1506
Compare To Biometric Samples
1508
Matches Local Bio Sample?
1510
YES
NO
Authenticate Received Biometric Information
1516
Send Biometric Information To SE Device Having Identifier Associated With Matching Bio Sample For Authenticaton
1512
Complete Transaction Responsive To Successful Authentication
1514

Figure 15

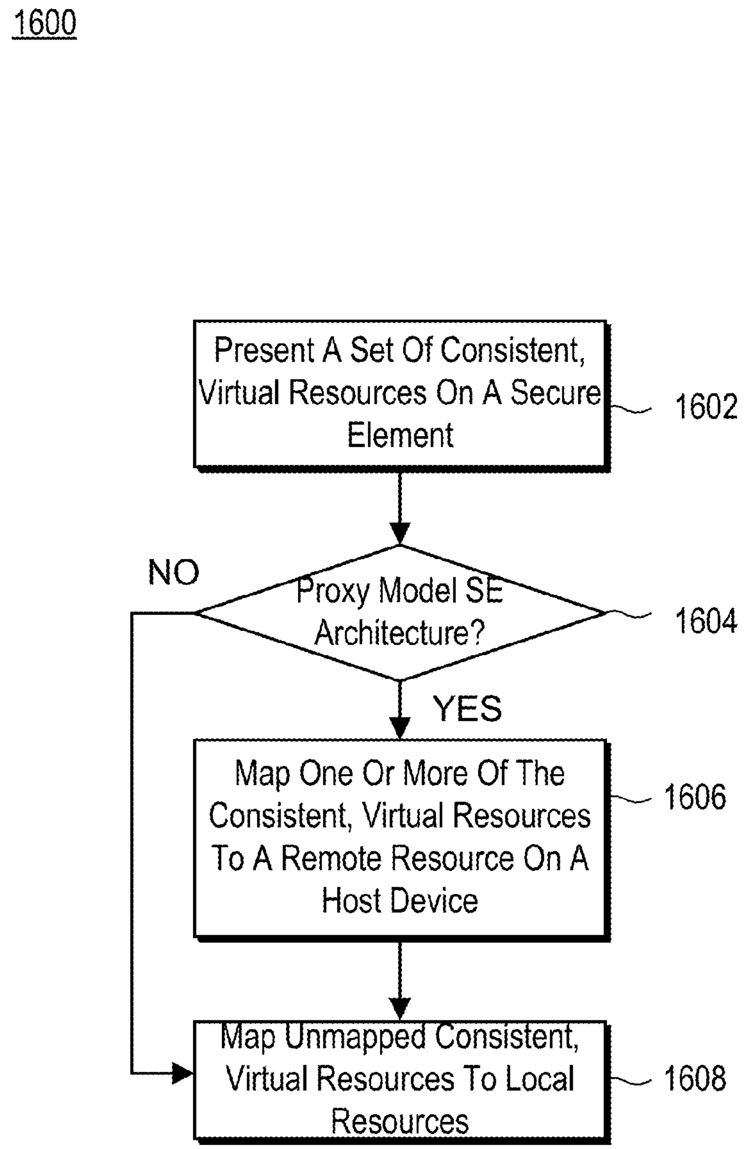
1600
Present A Set Of Consistent, Virtual Resources On A Secure Element
1602
Proxy Model SE Architecture?
1604
NO
YES
Map One Or More Of The Consistent, Virtual Resources To A Remote Resource On A Host Device
1606
Map Unmapped Consistent, Virtual Resources To Local Resources
1608

Figure 16

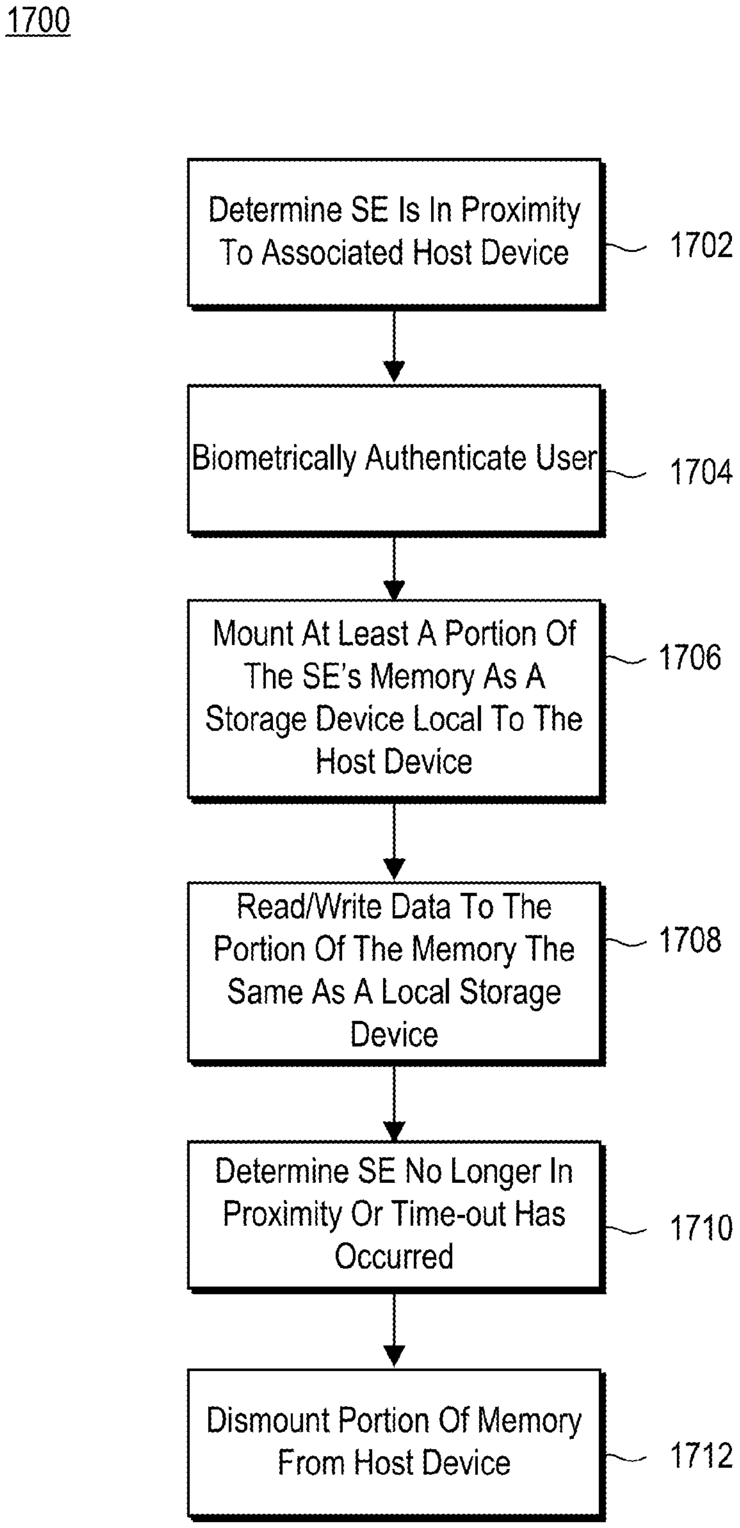
1700
Determine SE Is In Proximity To Associated Host Device
1702
Biometrically Authenticate User
1704
Mount At Least A Portion Of The SE's Memory As A Storage Device Local To The Host Device
1706
Read/Write Data To The Portion Of The Memory The Same As A Local Storage Device
1708
Determine SE No Longer In Proximity Or Time-out Has Occurred
1710
Dismount Portion Of Memory From Host Device
1712

Figure 17

SECURE ELEMENT AS A DIGITAL POCKET

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application No. 61/822,057, filed May 10, 2013, and of U.S. Provisional Patent Application No. 61/864,237, filed Aug. 9, 2013, the entire contents of both are incorporated herein by reference.

BACKGROUND

A typical individual will frequently participate in activities such as accessing a physical or digital object, securing a physical or digital object, conducting a transaction and storing/retrieving data. Such activities may be facilitated and secured using one or more items carried, for example, in a pocket, by the user. For example, an individual may carry a RFID or Bluetooth key to access and secure his/her home or office and a wireless key fob to access and operate his/her vehicle. The individual may also carry a physical wallet with a government issued identification, cards issued by financial institutions for accessing associated funds or completing transactions, and other cards issued by other entities (e.g. insurance cards, membership cards, rewards cards, etc.). The individual may also carry a storage device, for example, a USB thumb-drive for storing data. The individual may also carry and use a password manager for maintaining passwords for various objects (e.g. user accounts).

What is needed is a single device that consolidates the functionality and replaces the multiple, potentially bulky, items carried by an individual. What is further needed is for the device to be compatible with existing devices and systems in order to provide features and functionality such as authentication and proximity based access thereto.

SUMMARY

According to one innovative aspect of the subject matter described in this disclosure, a system comprises a secure element configured to wirelessly communicate directly with an associated host device, the secure element including a memory storing data and a wireless storage module executable by a processor of the secure element; and the associated host device including a link module executable by a processor, the link module of the associated host device cooperating with the wireless storage module of the secure element to wirelessly mount at least a portion of the memory as a storage drive of the associated storage drive.

Other aspects include corresponding methods, apparatus, systems and computer program products. These and other implementations may each optionally include one or more of the following features. For instance, a biometric sensor configured to obtain physical or behavioral characteristics from a user; and an identification module executable by the processor of the secure element to authenticate the user as an owner of the secure element based on the obtained physical or behavioral characteristic. For instance, one or more of the mounting of the portion of the memory and a user accessing the mounted portion of the memory is responsive successful authentication of the user as the owner of the secure element based on the obtained physical or behavioral characteristic. For instance, the biometric sensor is included in the secure element. For instance, the biometric sensor is included in the associated host device, but available to the secure element as a virtual biometric sensor via an abstraction layer. For instance, the wirelessly mounted portion of the memory appears to the host device as a storage drive physically connected to the host device. For instance, the mounting of the portion of the memory is based on one or more of a user configurable proximity and a user configurable duration of time for the secure element to be in proximity to the associated host device.

In general, another innovative aspect of the subject matter described in this disclosure may be embodied in methods that include presenting, to a secure element, one or more virtual resources; and mapping the one or more virtual resources to one or more available physical resources based on a model architecture for the secure element and to provide hardware abstraction, the available physical resources varying based on the model architecture and an associated host device, the virtual resources allowing consistent interaction with the virtual resources regardless of variation in the physical resources available and their location.

Other aspects include corresponding methods, apparatus, systems and computer program products. These and other implementations may each optionally include one or more of the following features. For instance, the model architecture is a proxy model architecture, the operations further including: mapping a first virtual resource to a first resource on the associated host device, and wherein the mapping allows the secure element to interact with the first virtual resource as if the first virtual resource is a local resource of the secure element, wherein the secure element and the associated computing device are physically separate devices. For instance, the model architecture is a proxy model architecture, the operations further including: performing, at the secure element, a functionality of the secure element, the associated host device wirelessly controlling the performance of the functionality, the secure element performing the functionality on behalf of the associated host device, wherein the associated host device is physically separate from the secure element. For instance, wherein the functionality of the secure element performed is one or more of an authentication and the execution of a financial transaction. For instance, the operations further including determining whether the security element is in proximity to the associated host device; and responsive to determining the secure element is in proximity to the associated host device, permitting access to the associated host device. For instance, the secure element may be associated with one or more additional host devices and permit access to the one or more additional host devices when in proximity to the one or more additional host devices. For instance, the operations further including: determining whether the security element is in proximity to the associated host device; and responsive to determining the secure element is in proximity to the associated host device, wirelessly mounting at least a portion of a memory of the secure element on the associated host device, the mounted portion of the memory appearing as a physically connected storage device at the associated host device. For instance, the secure element may be associated with one or more additional host devices and mounts the portion of the memory to the one or more additional host devices when in proximity to the one or more additional host devices. For instance, the model architecture is a stand-alone model architecture, and the one or more virtual resources are mapped to physical resources available on the secure element. For instance, the model architecture is a stand-alone model architecture, and the one or more virtual resources are mapped to physical resources available on the secure element. For instance, the model architecture is a virtual model architecture, and the one or more virtual resources are mapped to physical resources available on the host device, wherein the secure element is a virtual secure element operating on the associated host device, but appearing to other devices as a separate device. For instance the secure element is platform agnostic and operates the same regardless of a platform the associated host device is operating. For instance, the secure element is a single device that performs functionality of a thumb drive, a physical key, a logical key, a proximity based lock and performs user authentication.

The features and advantages described in the specification are not all inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and may not have been selected to delineate or circumscribe the disclosed subject matter.

BRIEF DESCRIPTION OF DRAWINGS

The specification is illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like reference numerals are used to refer to similar elements.

FIG. **1** is a block diagram illustrating an example system with secure elements according to one embodiment.

FIG. **2** is a block diagram illustrating an example of a secure element according to one embodiment.

FIG. **3** is a block diagram illustrating a stand-alone model variant of the secure element architecture according to one embodiment.

FIG. **4** is a block diagram illustrating a stand-alone model variant of the secure element architecture according to another embodiment.

FIG. **5** is a block diagram illustrating a proxy model variant of the secure element architecture according to one embodiment.

FIG. **6** is a block diagram illustrating a proxy model variant of the secure element architecture according to another embodiment.

FIG. **7** is a block diagram illustrating a virtual model variant of the secure element architecture according to one embodiment.

FIG. **8** is a block diagram illustrating a virtual model variant of the secure element architecture according to another embodiment.

FIG. **9** is a block diagram illustrating an example of a digital pocket engine according to one embodiment.

FIG. **10** is a block diagram illustrating an example of a secure element driver according to one embodiment.

FIGS. **11**A-C are illustrations of a secure element according to one embodiment.

FIGS. **12**A-F are illustrations of a secure element according to one embodiment.

FIG. **13** is a block diagram illustrating an example of secure element services according to one embodiment.

FIG. **14** is a flowchart of a method for authentication using a secure element according to one embodiment.

FIG. **15** is a flowchart of a method for a biometrically triggered transaction according to one embodiment.

FIG. **16** is a flowchart of a method for hardware abstraction based on a secure element architecture according to one embodiment.

FIG. **17** is a flowchart of a method for a secure element acting as a wireless storage device according to one embodiment.

The figures depict various embodiments for purposes of illustration only. It should be recognized from the following discussion that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles described herein.

DETAILED DESCRIPTION

FIG. **1** is a block diagram illustrating an example system with secure elements according to one embodiment. The illustrated system **100** includes secure elements (SE) **102***a*, **102***b* and **102***n*, host devices **120***a* and **120***b*, a network **110**, and secure element services **126**. In FIG. **1** and the remaining figures, a letter after a specific number, for example "**102***a*" may be a reference to the element having that particular reference number. A reference number without a following letter, for example "**102**," may be a general reference to the embodiments bearing that reference number.

In the illustrated embodiment, secure element **102***a* may wirelessly couple for bi-directional, secure communication with SE **102***b* by signal line **106***a*, with host device **120***a* by signal line **106***b* and with host device **120***b* by signal line **106***c*. Secure element **102***b* may also wirelessly couple for bi-directional, secure communication with host device **120***b* by signal line **106***d*. SE **102***n* may wirelessly couple for bi-directional, secure communication with host device **120***b* by signal line **106***e* and with network **110** by signal line **106***g*. Host device **102***a* may wirelessly couple for bi-directional, secure communication with SE **102***b* by signal line **106***a*, with host device **120***b* by signal line **106***f* (e.g. when a host device **120** includes a virtual SE as discussed below) and may couple for communication to network **110** by signal line **154**. Host device **102***b* may couple for communication to network **110** by signal line **152**. Secure element services **126** may couple to the network **110** by signal line **156** and provide various services to a host device **120**, a SE **102** or both via the network **110**.

It should be noted that the signal lines **106** for secure, wireless, bi-directional communication are not necessarily simultaneous. For example, signal line **106***a* may be established when SE **102***a* and host device **120***a* are within detection range and SE **102***a* may act as a proximity based key to allow access to the host device **120***a* (e.g. a work computer). Signal line **106***a* may be subsequently severed and when SE **102***a* is within detection range of host device **120***b* (e.g. a personal computer at home) the signal line **106***c* is established.

The SE **102** is a compact, portable, single point solution for authentication and enabling access. In one embodiment, the SE **102** provides a wireless thumb drive, authentication (including multi-factor and biometric), physical/logical access control and an e-wallet for use in financial transactions in a single device that is capable of replacing many of the items carried by a typical individual including, for example, keys, a wallet (e.g. ID, credit cards, insurance cards, membership cards, loyalty cards, etc.) and a thumb drive. Additionally, the SE **102** combines authentication, proximity sensing and biometrically-triggered interactions to conveniently reduce direct handling of and interaction with the SE **102** while maintaining security. While the illustrated embodiment includes three secure elements **102**, the disclosure herein applies to systems including at least one secure element (SE) **102**.

The network **110** may provide communication between one or more of an SE **102**, a host device **120**, secure element services module **126**. For example, an SE **102** may communicate location and tracking data to the secure elements services **126** using the network **110** and communication channel **156** via a secure, wireless communication channel **106** to the network **110** or a host device **102**.

In one embodiment, the network **110** uses standard communications technologies and/or protocols. Thus, the network **110** can include links using technologies such as Ethernet, 802.11, 802.16, integrated services digital network (ISDN), digital subscriber line (DSL), asynchronous transfer mode (ATM), 3G, 4G, Wi-Fi, etc. Similarly, the networking protocols used on the network **110** can include the transmission control protocol/Internet protocol (TCP/IP), the hypertext transport protocol (HTTP), the simple mail transfer protocol (SMTP), the file transfer protocol (FTP), etc. The data exchanged over the network **110** can be represented using technologies and/or formats including the hypertext markup language (HTML), the extensible markup language (XML), etc. In addition, all or some of links can be encrypted using conventional encryption technologies such as the secure sockets layer (SSL), Secure HTTP and/or virtual private networks (VPNs). In another embodiment, the entities can use custom and/or dedicated data communications technologies instead of, or in addition to, the ones described above. In some embodiments, the network **110** may include the Internet and/or the cellular data network.

A host device **120** is a computing device. Examples of host devices **120** include, but are not limited to desktop computers, laptops, tablets, cellular or smart phones, point of sale devices, etc. While the illustrated embodiment **100** includes two host devices **120**, some embodiments of a system with secure elements **102** may have a different number of host devices **120** or may lack a host device **120**. Additionally, it should be noted that the host devices **120*a*** and **120*b*** may be a mixture of different types of host devices **120**. For example, host device **120*a*** may be a smartphone and host device **120*b*** may be a desktop computer. Furthermore, the host devices **120*a*** and **120*b*** may run the same or different platforms, or operating systems. Examples of platforms may include, but are not limited to, Windows, Mac OS, Linux, iOS, Android, Blackberry, Fire OS, etc.

In one embodiment, the host device **120** includes at least one processor (not shown). Depending on the embodiment, the host device **120** may also include other elements including one or more of a memory (not shown), a storage device (not shown), a keyboard (not shown), a graphics adapter (not shown), a pointing device (not shown), a display device (not shown), one or more ports (e.g. serial, USB, Ethernet, etc.), one or more radio transceivers (e.g. Wi-Fi, Bluetooth, 3G/4G, etc.) and one or more sensors (e.g. a biometric sensor).

In the illustrated embodiment, host device **120*a*** includes SE driver **122*a*** and host device **120*b*** includes SE driver **122*b***. In one embodiment, a SE driver is stored in the host device's memory (not shown) and executed by the host device's processor (not shown). The SE driver **122** may facilitate setup of the SE **102**, communication with a SE **102** and enable an SE **102** to be associated with the host device **120** and cooperate with the SE **102** to provide the functionality described herein. For example, the SE driver **122** enables the SE **102** to act as a proximity based lock for the host device or a physical or logical asset accessible thereby and to act as a secure, wireless storage device. The SE driver **122** is discussed further with reference to FIG. **10** below.

The host device **120** may also include one or more applications (not shown), which may be stored in the host device's memory (not shown) and executed by the host device's processor (not shown). The one or more applications may use an API and the SE driver **122** to request, control and facilitate some of the functionality provided by the SE **102** as described herein. For example, in one embodiment, a smartphone application for a retailer may use an API and the SE driver **122** to have the SE **102** authenticate the user and complete a financial transaction on behalf of the application.

As is known in the art, a host device **120** can have different and/or other components than those mentioned herein. In addition, the host device **120** can lack certain listed components. As is known in the art, the host device **120** and SE **102** are adapted to execute computer program modules for providing functionality described herein. As used herein, the term "module" refers to computer program logic utilized to provide the specified functionality. Thus, a module can be implemented in hardware, firmware, and/or software. In one embodiment, program modules are stored on the storage device loaded into the memory, and executed by the processor.

Embodiments of the entities described herein can include other and/or different modules than the ones described here. In addition, the functionality attributed to the modules can be performed by other or different modules in other embodiments. Moreover, this description occasionally omits the term "module" for purposes of clarity and convenience.

FIG. **2** is a block diagram illustrating an example of a secure element (SE) **102** according to one embodiment. The SE **102** includes a processor **203** and a memory **205**. In some embodiments, the SE **102** may include additional elements including a power source **202**, an input/output ("I/O") interface **208**, radio/port **222**/**224**/**226** and a bio sensor **230**.

The memory **205** is any device capable of holding data and may include one or more of a hard drive, compact disk read-only memory (CD-ROM), DVD, RAM or a solid-state memory device. The memory **205** may include a read-only memory, a once-programmable memory, a read/write memory or any combination of memory types including physical access secured and tamperproof memories. For example, in one embodiment, the It should be recognized that the preceding are merely examples and other memories may be present and that the memory may be physically or logically partitioned. For example, in one embodiment, the memory **205** is physically partitioned and comprised of multiple memories, e.g., a built-in, solid state memory storing an operating system, unique ID associated with the SE **102** and the digital pocket engine **204**, and a removable memory such as a SIM card. In one embodiment, the SIM card is logically partitioned into portions that are controlled by the digital pocket engine **204** and portions that are protected by the digital pocket engine **204**. The memory **205** or portions thereof may be secured (i.e. secure memory **206**) for example using encryption and other methods.

In one embodiment, there are multiple types of SEs **102**. See Appendix A. For example, in one embodiment, an SE **102** may be of a personal security element ("PSE") type or of a general security element ("GSE") type. In one embodiment, an SE's **102** type is determined based on the intended use and the user data stored. For example, a PSE may be intended for personal use and persistently stores user data and biometrics of the owner and a GSE may be intended for general (or non-personal) use and stores no user data and biometrics persistently. In one embodiment, a PSE is carried by a user and associated with the user and a GSE is associated with a device such as check-out station in a business. In one embodiment, both a PSE and a GSE may store in memory **205**/**206** one or more of a unique ID, public name, available service, Stationary/Mobile, location data and application specific service blocks; however, a PSE may also store biometric data or other personal data of the owner.

The processor **203** executes instructions and routines to perform the functionality of the SE **102** described herein. In one embodiment, the processor **203** is a central processing unit (CPU). The power source **202** may include a battery, such as a rechargeable lithium ("Li") ion battery. In one embodiment, the battery is rechargeable via one of the radio/ports **222**/**224**/**226** (e.g. a USB port).

A radio/port **222**/**224**/**226** may be a radio transceiver or a port. Examples of radio transceivers may be transceivers for Bluetooth, Wi-Fi, near-field communication (NFC), 3G/4G, DNLA, etc. Examples of ports include USB, mini-USB, micro-USB, serial, Firewire, HDMI, etc. In the illustrated embodiment, three radio/ports **222**/**224**/**226** are shown; however, the SE **102** may include one or more radio/ports. Additionally, the radio/ports **222**/**224**/**226** may be a mixture of different radio transceivers, ports or both. In one embodiment, at a minimum, a SE **102** includes at least one radio transceiver capable of communicating with other SEs **102**.

The bio sensor **230** is a sensor for receiving biometric information describing a physical or behavioral characteristic from a user. For clarity and convenience, the result of fingerprint scan and a fingerprint reader/scanner are occasionally used throughout the description as an example of biometric information and a biosensor **230**, respectively. However, the biometrics and bios sensors **230** are not merely limited to fingerprints. Other examples of biometrics include a retinal scan, an iris scan, a facial scan, a voice sample, a signature, DNA, RNA or any other suitable biometric, and the biometric sensor **230** may be a sensor(s) suitable for capturing the biometric (e.g. camera for face, microphone for voice, touch pad for signature, etc.).

The I/O interface **208** is an interface between the digital pocket engine **204** and the radio/ports **222**, **224**, **226** and bio sensor **230**. In one embodiment, the SE **102** includes an abstraction layer **220** that enables the I/O interface **208** to utilize resources without regard to those resources' physical attributes, settings or locations.

In one embodiment, the abstraction layer **220** does this by presenting virtual, consistent resources **210**, **212**, **214**, **216**, **218** to the I/O interface **208**, announces the secure element architecture (discussed below with reference to FIGS. **3**-**8**), announces the onboard resources and requested resources to another device (e.g. another SE **102** or a host device **120**), and maps the virtual resources **210**, **212**, **214**, **216**, **218** to available, on-board resources and, when requested and permitted by the secure element architecture, to resources of another device.

For example, certain actions in the system **100** may require that the user provide biometric information for authentication. In some embodiments, depending on the action being taken or the SE(s) **102** and host device(s) **120** involved in the action, a user may be required to provide the biometric information locally (e.g. using the bio sensor **230** on his/her SE **102**), or remotely (e.g. using the bio sensor on another user's SE **102** or on a host device **120** and received at the SE **102** via a port/radio **222**/**224**/**226**). In one embodiment, the abstraction layer **220** maps the virtual bio sensor **216** to the appropriate sensor whether the local bio sensor **230** or a remote sensor (e.g. via radio/port **1 222**) and the I/O interface **208** interacts with the received biometric information the same regardless of whether the user's biometric information is obtained locally or remotely.

As previously alluded to, the SE **102** is capable of operating using a variety of model architectures. In one embodiment, the architectural variants include stand-alone model without an external communication link (See FIG. **3**), stand-alone model with an external communication link (See FIG. **4**), proxy model without sharing resources (See FIG. **5**), proxy with sharing resources (FIG. **6**), virtual, stand-alone model without an external communication link (See FIG. **7**) and virtual, stand-alone model with an external communication link (See FIG. **8**). It should be noted that "external communication link" as used with respect to the model architectures refers to whether the SE **102***a* communications link exists with an external host device **120**.

FIG. **3** is a block diagram illustrating a stand-alone model without an external communication link variant of the secure element architecture according to another embodiment. FIG. **4** is a block diagram illustrating a stand-alone model with an external communication link variant of the secure element architecture according to another embodiment. FIG. **5** is a block diagram illustrating a proxy model without sharing resources variant of the secure element architecture according to one embodiment. FIG. **6** is a block diagram illustrating a proxy model with sharing resources variant of the secure element architecture according to another embodiment. FIG. **7** is a block diagram illustrating a virtual model without an external communication link variant of the secure element architecture according to one embodiment. FIG. **8** is a block diagram illustrating a virtual model with an external communication link variant of the secure element architecture according to another embodiment. See Appendix A.

Before discussing the variants of the secure element architecture, it is worth mentioning that, regardless of the secure element architecture, the SE **102** is able to perform the same core functionality including, multi-factor/multi-type authentication with or without biometrics and with or without utilizing a cloud-based central registry, secure access control, secure transactions, location tracking, and secure data storage services.

Referring now to FIGS. **3** and **4**, in the stand-alone model architecture, the SE **102** uses its own, local resources and logic to perform the core, functionalities such as multi-factor/multi-type authentication with or without biometrics and with or without utilizing a cloud-based central registry, secure access control, secure transactions, location tracking, and secure data storage services. When the SE **102** uses this architecture, the abstraction layer **220** maps the virtual resources **210**, **212**, **214**, **216**, **218** thru to the SE's **102** (local) sensors, radios, and ports.

Referring now to FIGS. **5** and **6**, in the proxy model architecture, according to one embodiment, the host device **120** may control, access and interact with the SE **102**. For example, an application on the host device **120** may control the SE **102** to authenticate the user, and upon successful authentication of the user, use information of the SE **102**'s e-wallet (e.g. a credit line) to conduct a financial transaction on behalf of the host device **120**. In the proxy model architecture, according to one embodiment, the SE **102** may control, access and interact with the host device **120**. For example, the SE **102** may independently authenticate a user biometrically and/or using a central registry and lock/unlock a door, an automobile, or any number of other associated host devices **120**. In the proxy model architecture, according to one embodiment, the host device **120** and SE **102** may share (virtualize) a resource of the host device **120**. For example, assume the host device **120** has a sensor that the SE **102** does not (e.g. a retinal scanner); in one embodiment, the proxy model architecture allows that sensor of the host device **120** to serve its role as if directly built into the SE **102**. Therefore, the proxy model architecture opens up many new roles and capabilities.

Referring now to FIGS. **7** and **8**, in the virtual, stand-alone model architecture, the host device **120** installs software (not shown) and the software provides virtualized SE functionality, i.e., the virtual SE software uses the host device's **120** sensors, ports, and memory to create what appears to be a stand-alone SE to any other device interacting with it. This virtual architecture may be useful for host devices **120** such as existing smartphones, tablets and other computing devices where convenience and ease are more important than maximized security.

A distinction between the proxy model architecture and the virtual, stand-alone model architecture is the location of the SE's secure memory **206** and SE-to-SE radio. The proxy model architecture maintains these elements in the SE **102** device, but in the virtual, stand-alone model architecture, these elements are included in the host device **120**. An advantage of the stand-alone and proxy model architectures is that the SE related data is in the SE **102** and separate from the host device **120**. This makes upgrading a host device (e.g. a smartphone) a non-issue as the user's data (e.g. biometrics and other secure data such as the data from the phone's applications, contact list, etc.) is stored on the SE **102** and not on the host device **120**. Therefore, a user need only install the SE driver **122** on the new host device **120** and associate the SE **102** with the new host device **120**. In one embodiment, the SE **102** storing other secure data may allow a user to use another individual's device without worrying about security. For example, in one embodiment, the user's contact list is stored to the SE **102**, so when the user picks up any host device **120** with the SE driver **122** installed, the user can access that contact list on the host device **120**, and perhaps even place a call, text, retrieve data using his/her phone plan and billing information.

The SE **102** may use different secure element architectures at different times in different scenarios, sometimes referred to as a balanced model. For example, in one embodiment, the SE **102** could act use the stand-alone architecture to act as a purchaser in a first transaction and use the proxy architecture to act as a merchant in a second transaction. In another example, in one embodiment, the balanced model allows two SEs **102** (e.g. a GSE and a PSE) to participate in a single transaction. Thus, the SE **102** may fulfill the roles of both the mobile component and stationary component, which typically are distinct, dedicated devices in other systems and often in those other systems the mobile component may not directly communicate with a host device, but must communicate with the stationary component that is integrated into or coupled to a host device.

FIG. **9** is a block diagram illustrating an example of a digital pocket engine **204** according to one embodiment. In one embodiment, the digital pocket engine **204** includes a wireless storage module **902**, an identification module **904**, an access control module **906** and a wallet module **908**. In one embodiment, the modules of the digital pocket engine **204** are coupled to each other via a bus (not shown). Persons having ordinary skill in the art will recognize that some of the modules could run as separate applications on a SE **102**.

The wireless storage module **902** can be software including routines for enabling the SE **102** to act as a wireless, portable data store. In some embodiments, the wireless storage module **902** can be a set of instructions executable by the processor **203** of the SE **102** to provide the functionality described below for wireless, portable data storage. In some embodiments, the wireless storage module **902** can be stored in the memory **205** of the SE **102** and can be accessible and executable by the processor **203**. In some implementations, the wireless storage module **902** can be adapted for cooperation and communication with the processor **203** and other components of the SE **102**.

Existing thumb drives must be physically connected (e.g. using a USB port) to a host device **120** (e.g. a personal computer) in order to access or modify the data stored on the thumb drive. Such devices are less than ideal. For example, a user must physically interact with the thumb drive to retrieve the thumb drive from a pocket, locate a compatible physical connection (e.g. a USB port) on the host device **120** if there even is one, orient the physical connections of the thumb drive to that of the host device **120** and create the physical connection. Such interactions may be inconvenient for a number of reasons. For example, the user has many/large/full pockets and must sift through the contents to locate the thumb drive; the physical connections of the host device **120** may be inconveniently located (e.g. on the back of a personal computer tower located under a desk), and the thumb drive may be left behind or forgotten by the owner when the owner is finished. In some embodiments, the SE **102** and the functionality provided at least in part by the wireless storage module **902** beneficially reduce or eliminate one or more of the inconveniences associated with existing thumb drives.

The wireless storage module **902** provides wireless, portable data storage functionality. In one embodiment, the wireless storage module **902** of the SE **102** determines whether the SE **102** is in proximity to an associated host device **120**, i.e., a host device **120** with which the SE has a relationship or is "associated" with. For example, assume a first user owns SE **102*b*** and host device **120*b*** and has associated SE **102*b*** with host device **120*b***; in one embodiment, the wireless storage module **902** determines when SE **102*b*** is in proximity to host device **120*b***.

In one embodiment, the proximity is determined based on a metric satisfying a threshold, for example, a signal strength of a wireless connection between the SE **102** and the host device **120**. In one embodiment, the proximity may be a variable threshold. For example, so that a SE **102** needs to be closer to a first host device **120** than a second host device **120** to be determined proximate. Such an embodiment, may beneficially provide greater security by requiring that a user be closer to a host device **120** that is portable or used publicly (e.g. a cellular phone) than to a stationary or private host device (e.g. a desktop computer in a user's private bedroom). Depending on the embodiment, the proximity threshold varies based on one or more of any number of factors including, for example, a user preference, the host device **120**, the type of host device **120**, etc.

In one embodiment, wireless storage module **902** wirelessly mounts the memory **205** of the SE **102** or a portion thereof as storage drive on the associated host device **120** in proximity. In one embodiment, the wireless storage module **902** automatically mounts at least a portion of the SE **102** memory **205** as a drive of the host device **120** responsive to determining the host device **120** is within proximity. In one embodiment, the wireless storage module **902** may require one or more triggers prior to mounting, for example, to prevent potential repeated, unwanted or unnecessary mounting as the user walks with a SE **102** in and out of proximity to the host device **120**. Examples of triggers may include biometric authentication (e.g. the user swiping his or her finger on a fingerprint reader), a duration of time for the SE **102** to be in proximity being satisfied (which may or may not be user adjustable), etc.

In one embodiment, the mounted portion of the SE's memory **205** is treated by the host device **120** as if it was an internal drive or a physically connected thumb drive and allows data (e.g. files, documents, etc.) to be read from and written to the memory **205** as such while the SE **102** remains in the user's pocket, purse, backpack, etc. Therefore, the wireless storage module **902** revolutionizes the carrying of digital content by making the process easier, quicker and more secure.

In one embodiment, the wireless storage module **902** may interact with the identification module **904** to require biometric authentication. For example, the identification module **904** of the SE **102** may authenticate a fingerprint before mounting the portion of the memory **205** or allowing a user to access the mounted portion of the memory **205**.

The identification module **904** can be software including routines for performing authentication. In some embodiments, the identification module **904** can be a set of instructions executable by the processor **203** of the SE **102** to provide the functionality described below for authentication. In some embodiments, the identification module **904** can be stored in the memory **205** of the SE **102** and can be accessible and executable by the processor **203**. In some implementations, the identification module **904** can be adapted for cooperation and communication with the processor **203** and other components of the SE **102**.

In one embodiment, the identification module **904** manages identifying information, e.g., biometrics, name, address, phone number, driver's license, passport, social security number, business card, insurance cards, etc., stored on the SE **102**, thereby potentially and beneficially eliminating the need for the owner user to carry such items in a wallet or pocket. In one embodiment, as described above with reference to the proxy model architecture, the identification module may perform authentication on behalf of the host device **120** or application thereof.

In one embodiment, the identification module **904** performs authentication. In one embodiment, the identification module **904** performs authentication using one or more factors including, for example, one or more of a device, a user, an application and a registry or other trusted third party. Upon successful authentication, the SE **102** establishes a secure, wireless communication channel **106** over which data may be securely exchanged.

In one embodiment, the identification module **904** performs device authentication (i.e. SE-to-SE authentication). See Appendix B. For example, in one embodiment, when SEs (e.g. SE **102*a*** and SE **102*b***) detect one another they automatically establish a secure, wireless communication link (e.g. **106*a***) and exchange information and based on that information confirm the other device is a valid SE **102**.

In one embodiment, the identification module **904** performs user authentication (i.e. SE-to-User authentication). See Appendix B. For example, in one embodiment, the identification module **904** may require that the user provide biometric information by interaction with a bio sensor **230** and authenticate the user the identification module determines that the biometric information of the user matches that of the owner of the SE **102** stored during setup of the SE **102**.

In one embodiment, the identification module **904** performs application authentication (i.e. SE-to-App authentication). See Appendix B. For example, in one embodiment, the identification module **904** sends data to an application on the host device **120** for the application to authenticate that the SE **102** is a valid device. In another example, in one embodiment, the identification module **904** may receive data (e.g. a certificate or checksum) from an application of the host device **120** that verifies the application is valid (e.g. is valid and has not been altered).

In one embodiment, the identification module **904** performs registry authentication (i.e. SE-to-Registry authentication). See Appendix B. For example, in one embodiment, the identification module **904** sends data to a registry (e.g. a central registry) and receives from the registry a determination whether the SE **102** is in good standing, is lost, stolen, etc.

The authentication performed by the identification module **904** may depend on a service the SE **102** is providing. In one embodiment, services include private services and external services. For example, in one embodiment, private services are further categorized as owner/personal (OP) and multi-party (MP) and external services include a third party trusted (TPT) category. See Appendix B.

In one embodiment, Private-OP services are services that require the owner of the SE **102** to accept. In one embodiment, an owner accepts a Private-OP service by being biometrically authenticated. For example, the user swipes his or her finger on the fingerprint reader of their SE **102** and upon authentication, the service is available or provided. Examples of Private-OP services may include storing or accessing private files on the SE **102** or host device **120** or accessing a host device **120** (e.g. via the wireless storage module **902**); and accessing devices, equipment, doors, websites, applications, filling out online forms, etc. (e.g. via the access control module **906**).

In one embodiment, Private-MP services are services that require multiple parties to accept. In one embodiment, the multiple parties may accept the Private-MP service by being biometrically authenticated. For example, each user swipes his or her finger on the fingerprint reader of his/her own SE **102** (or depending on the embodiment, another user's SE **102** and the biometric information is exchanged for authentication) and upon biometric authentication of each user by the user's SE **102**, the service is available or provided. Examples of Private-MP services may include storing or accessing private files on the SE **102** or host device **120** or accessing a host device **120** (e.g. via the wireless storage module **902**); and accessing devices, equipment, doors, websites, applications, filling out online forms, etc. (e.g. via the access control module **906**).

In one embodiment, Public-TPT services are services that require acceptance by a trusted third party. In one embodiment, the service is accepted/approved when an owner provides biometric information at the accepting party's SE **102**. For example, assume user **1** wants to approve a secure file transfer to user **2** (i.e. the accepting party); in one embodiment, user **1** swipes his finger on the fingerprint reader of user **2**'s SE **102**. In another example, a user swipes his or her finger on the fingerprint reader of an SE **102** associated with the trusted third party (e.g. an SE **102** belonging to a notary agent of the trusted third party). Examples of Public-TPT services may include transferring secure files (e.g. via the wireless storage module **902**), performing secure transactions (e.g. via wallet module **908**), and accessing public devices, equipment, doors, etc. (e.g. via the access control module **906**).

The access control module **906** can be software including routines for enabling access control. In some embodiments, the access control module **906** can be a set of instructions executable by the processor **203** of the SE **102** to provide the functionality described below for access control. In some embodiments, the access control module **906** can be stored in the memory **205** of the SE **102** and can be accessible and executable by the processor **203**. In some implementations, the access control module **906** can be adapted for cooperation and communication with the processor **203** and other components of the SE **102**.

The access control module **906** enables the SE **102** to act as a proximity based key allowing access when in proximity and disallowing access when the SE **102** is not in proximity. The access control module **906** and the functionality provide thereby allows the SE **102** to replaces logical keys (e.g. username and passwords, PINS, etc.) and physical keys (e.g. car key fob, home and office keys including RFID keys, Bluetooth key, smart cards, etc.)

In one embodiment, the access control module **906** provides automated password management. In one embodiment, the access control module **906** automatically and invisibly fills in usernames and passwords when visiting websites, using apps, etc.

In one embodiment, the access control module **906** enables the SE **102** to act as a wireless, proximity based key to access and secure an associated host device **120** or other asset. Such access control beneficially makes a lost or stolen host device **120** unusable. Depending on the embodiment, the access control module **906** may secure and provide access to a host device **120** in one or more ways. In one embodiment, the operating system of the host device **120** may not be able to boot without the SE **102** in proximity. In one embodiment, the hard drive or other memory of the host device **120** may be encrypted and unusable when the SE **102** is not in proximity to provide the decryption key. In one embodiment, the access control module **906** automatically provides a username and password to log into an account on the host device **120**. For example, the access control module **906** auto completes the windows login on a host device **120** running the windows platform.

The proximity used for access control may be the same proximity as that used by the wireless storage module **902** or a different proximity depending on the embodiment. In one embodiment, the access control module determines proximity for access control similar to what is described with reference to the wireless storage module **902** above.

The wallet module **908** can be software including routines for enabling the SE **102** to serve as an e-wallet and participate in financial transactions. In some embodiments, the wallet module **908** can be a set of instructions executable by the processor **203** of the SE **102** to provide the functionality described below to serve as an e-wallet and participate in financial transactions. In some embodiments, the wallet module **908** can be stored in the memory **205** of the SE **102** and can be accessible and executable by the processor **203**. In some implementations, the wallet module **908** can be adapted for cooperation and communication with the processor **203** and other components of the SE **102**.

The wallet module **908** may store and manage electronic versions of one or more of the SE **102** owner's credit cards, debit cards, loyalty cards, membership cards, coupons and rewards cards, thereby eliminating the user's need to carry those items in his/her pocket or wallet.

In one embodiment, the wallet module **908** completes financial transactions. For example, the wallet module may complete a financial transaction responsive to the identification module **904** receiving approval and performing biometric authentication. In one embodiment, as described above with reference to the proxy model architecture, the wallet module **908** may perform financial transactions on behalf of the host device **120**.

In one embodiment, the wallet module **908** and identification module **904** enable biometrically triggered transactions. See Appendix A. In one embodiment, an SE **102** will automatically detect and initiate a connection to another SE **102** in range and, as mentioned, certain transactions may require a user to use a bio sensor of a host device **120** or another SE **102** (i.e. not the PSE of the user). When multiple SE **102** devices are within range of the device receiving the biometric information, the issue becomes determining which SE **102** is the SE **102** of the user that provided the biometric information in order to proceed with the transaction. In one embodiment, a SE **102** automatically and algorithmically matches received biometric information to the correct SE **102** for authentication. In one embodiment, when an SE **102** detects another SE **102** in range, the two SEs **102** automatically connect and communicate. In one embodiment, an SE **102** that is a PSE may send a biometric sample to the other SE **102** upon connecting.

As mentioned above, a PSE may store biometric information of the PSE's owner (e.g. data representing the owner's fingerprint). In some embodiments, the PSE also stores a sample, i.e. a subset, of that biometric information (e.g. data representing a portion of the owner's fingerprint). The biometric information and biometric sample may be created during setup of the PSE. In one embodiment, the biometric information and biometric sample may be created using one-way hash so that the user biometrics (e.g. fingerprint) cannot be recreated from them.

In one embodiment, a SE **102** may buffer the biometric samples it receives from other SEs **102** along with information identifying which SE **102** each biometric sample belongs to (e.g. by associating the sample with a unique identifier of the sending SE **102**). When a bio sensor of the buffering SE **102** is used and receives biometric information, in one embodiment, the SE **102** compares the biometric information to the buffered biometric samples and, depending on the embodiment, its own biometric sample when the SE **102** is a PSE and determines whether the received biometric information matches a sample. When a match is made the biometric information received from the bio sensor is sent to the identified SE **102** where the biometric information is authenticated by the identified SE **102**. Upon authentication, the SE **102** completes a transaction.

Such biometrically triggered transactions beneficially allow a user to initiate and complete a transaction merely by interacting with a bio sensor. For example, assume an individual with a PSE is checking out at a store and there is a line of other individuals each carrying their own PSE. The individual checking out may interact with a bio sensor on a GSE at the point of sale (e.g. swipe his or her finger) and automatically initiate and complete the payment process without the individual having to retrieve his/her PSE or take any other actions.

FIG. **10** is a block diagram illustrating an example of a secure element driver **122** according to one embodiment. The SE driver **122** may be a software application installed onto the host device **120**. In one embodiment, the SE driver **122** is platform agnostic and may be installed on any popular host device **120** platform, for example, Windows, Mac, Android, iOS, Blackberry, etc. In another embodiment, multiple SE drivers **122** for various host device **120** platforms may exist and the appropriate SE driver **122** for the host device's platform is installed on the host device **120**. Regardless of the embodiment, the SE **102** functions identically regardless of the host device's platform and is occasionally said to be platform agnostic or device independent. The platform independence and the implementation of the SE as either a separate device **102** or as a virtual SE on the host device beneficially provide for a system with unprecedented versatility. For example, the SE system **100** may be implemented with currently existing host devices **120** without modification to their hardware. For example, the SE **102** herein may work with a current smartphone, tablet and laptop to provide after-market proximity based access control to all without requiring any proprietary or specialized hardware being installed during manufacture of those devices.

In one embodiment, the secure element driver includes a setup module **1002**, a SE link module **1004** and a lock module

1006. In one embodiment, the modules of the secure element driver **122** are coupled to each other via a bus (not shown). Persons having ordinary skill in the art will recognize that some of the modules could run as separate applications on a host device **120**.

The setup module **1002** can be software including routines for setting up a SE **102**. In some embodiments, the setup module **1002** can be a set of instructions executable by a processor (not shown) of the host device **120** to provide the functionality described below for setting up a SE **102**. In some embodiments, the setup module **1002** can be stored in a memory (not shown) of the host device **120** and can be accessible and executable by its processor (not shown). In some implementations, the setup module **1002** can be adapted for cooperation and communication with the processor (not shown) and other components of the host device **120** and with the SE **102**.

Once the SE driver **122** is installed, an owner of a SE **102** may associate his/her SE **102** with the host device **120**. In one embodiment, a host device **120** may be associated with one or more SE **102***s*. An association between a host device **120** and an SE **102** is a relationship that allows some of the functionality described above. For example, proximity based access to the host device **120** and wireless data access of data stored on the SE **102** by the host device **120** both require that the SE **102** and host device **120** be associated according to one embodiment and will not occur absent the association.

The setup module **1002** allows a user to setup a new SE **102**. For example, in one embodiment, the setup module **1002** provides a user a wizard and/or GUIs which guide the user in the SE **102** setup and obtain the required information. For example, the setup module **1002** prompts the user to enter basic info and swipe a bio sensor. The biometric information is permanently and securely stored on the SE **102** (e.g. in a write only portion of the secure memory **206**) and subsequently used for biometric authentication. Once SE **102** is setup, a user need only carry (e.g. in a pocket) the SE **102** and swipe his or her finger when proof of ownership is required.

In one embodiment, the setup module **1002** may include software for implementing a virtual SE on the host device **120** as discussed with reference to the virtual model architecture. In another embodiment, the software for implementing a virtual SE on the host device **120** is software (not shown) that is separate from the SE driver **122** and the setup module **1002**.

The SE link module **1004** can be software including routines for extending the functionality and capabilities of an SE **102** to a host device **120**. In some embodiments, the SE link module **1004** can be a set of instructions executable by the processor (not shown) of the host device **120** to extend the functionality and capabilities of an SE **102** to the host device **120**. In some embodiments, the SE link module **1004** can be stored in the memory (not shown) of the host device **120** and can be accessible and executable by the processor (not shown). In some implementations, the SE link module **1004** can be adapted for cooperation and communication with the processor (not shown) and other components of the host device and with the SE **102**.

The link module **1004** extends the capabilities of the SE **102** to an associated host device **120**. In one embodiment, the link module **1004** contributes to enabling the proxy model architecture discussed above. For example, the link module **1004** contributes to enabling the host device **120** to control the SE **102** and/or contributes to enabling a SE **102** to share a resource of the host device **120** as if the resource was local to the SE.

In one embodiment, once a SE **102** is linked to an associated host device **120**, the SE **102** appears to the host device's application(s) as if the SE **102** was built into the host device **120** similar (from the host device's perspective) to any other sensor or hardware of the host device **120**. In one embodiment, the link module **1004** achieves this extension of capabilities by using its own abstraction layer on the host device **120** side. For example, referring to FIGS. **5** and **6**, the abstraction layer **520** may map the SE **102** connected wirelessly via radio/port **1 522** to locally available resources. For example, the abstraction layer **520** may map the secure element to USB port **1 510**, so that the SE **102** appears to the host device **120** and its applications the same a thumb drive plugged into USB port **1** of the host device **120**. The proxy pipe managers **228**, **524** act as conduits over which the shared resources are shared and managed and make the sharing of resources transparent to the SE **102** and host device **120**.

The lock module **1006** can be software including routines for enabling the SE **102** to act as a wireless, portable data store. In some embodiments, the lock module **1006** can be a set of instructions executable by the processor (not shown) of the host device **120** to provide the functionality described below for wireless, portable data storage. In some embodiments, the lock module **1006** can be stored in the memory (not shown) of the host device **120** and can be accessible and executable by the processor (not shown). In some implementations, the lock module **1006** can be adapted for cooperation and communication with the processor (not shown) and other components of the host device S and with the SE **102**.

The lock module **1006** enables an SE **102** associated with the host device **120** to perform some of the functionality described above with reference to the digital pocket engine **204**. For example, the lock module **1006** cooperates with the access control module **906** of the SE **102** so that the SE **102** acts as a digital key needed for a user to interact with and access the host device **120**, When the SE **102** is in proximity, the host device **120** works. When the SE **102** is not in proximity, the host device **120** does not work. Therefore, if the host device (e.g. a cell phone) is lost or stolen, the data thereon is protected and the host device **120** is useless to anyone who finds it. In some embodiments, sensitive data or other user data is stored on the SE **102**, so there is no data lost in the preceding scenario. The user may replace the lost or stolen host device **120** associate it with his/her SE **102** and be back to the status quo before the loss or theft.

It should be recognized that many of the features and functions described herein require an SE **102** and host device **120** to cooperate and communicate. For example, the remote wireless storage device capability and proximity based access to the host device **120** are two functions that require the SE **102** and the host device **120** to cooperate. The preceding description attributes certain functionality to module(s) on a specific device. For example, proximity determination is discussed with reference to one or more modules of the SE **102**. However, it should be recognized that some functionality may be divided differently among the SE **102** and host device **120**. For example, in one embodiment, the lock module **1006** may determine proximity in addition to or instead of the access control module **906**.

FIGS. **11**A-C are illustrations of a secure element **102** according to one embodiment. Referring to FIG. **11**A-C, the illustrated SE **102** embodiment includes a male USB port **1102**, which may be extended (as seen in FIG. **11**A) or retracted (and is not visible in FIGS. **11**B and **11**C) when a user slides the USB actuator pad **1104** in a groove **1106** from a first position (as seen in FIG. **11**A) to a second position (as seen in FIGS. **11**B and **11**C). The USB port **1102** may be used to charge a rechargeable battery (e.g. Li ion) of the SE **102**, update the SE's **102** software including firmware, and utilize the SE **102** without a wireless connection (e.g. as a traditional thumb drive, a general security element with a biometric reader for the host device **120**, etc.).

The illustrated SE **102** embodiment also includes indicator lights **1108** and **1110**. For example, an indicator light **1108** (e.g. a blue LED) to indicate whether the SE **102** is charging or fully charged (e.g. when plugged into a USB charging cable or USB port on a host device **120**) and one or more indicator lights **1110** to indicate whether an authentication or portion thereof was successful (e.g. a green LED to indicate a successful biometric reading and a red LED light to indicate a biometric read failed). The illustrated SE **102** embodiment also includes a fingerprint reader **1114** and a groove **1112** in the housing of the SE **102** to guide a user's finger across the fingerprint reader **1114**. Referring now to FIGS. **11**B-**11**C, an example of a USB cover/keychain connector **1116** is shown, which may be connected to the end of the SE **102** with the USB port in order to cover the USB port and provide an anchoring loop to attach the SE **102** to a lanyard, keychain or other item.

FIGS. **12**A-F are illustrations of a secure element **102** according to one embodiment. FIGS. **12**A-F show a SE **102** similar to that illustrated in FIGS. **11**A-C, but offer a different perspective view. For example, FIG. **12**D is similar to FIG. **11**A, FIG. **12**B is similar to FIG. **11**B and FIGS. **12**E and **12**F are similar to FIG. **11**C.

FIG. **13** is a block diagram illustrating an example of secure element services **126** according to one embodiment. In one embodiment, the secure element services **126** provides various services related to or expanding on the functionality of the SE **102** described above. In the illustrated embodiment, the secure element services includes a registration server **1302** and central registry **1304**, a backup server **1306** and backup data **1308**, a tracking server **1310** and tracking data **1312**, and an alert server **1314** and alert conditions. See Appendix A and B.

The registration server **1302** allows an owner of a SE **102** to register his/her SE **102**. Registration may provide a number of benefits. For example, registration using a trusted third-party authority may ensure that the owner of the SE **102** and the provider of any biometric information stored to the SE **102** is who he/she purports to be. For example, in some embodiments, a notary agent may be required to witness a user's setup of an SE **102** and register the SE **102**. For example, a user may be required to present government issued identification to a notary agent. The notary agent may then confirm the user's identity is consistent with the identification presented and witness the user's setup and storage of his/her biometric information onto the SE **102**. In one such embodiment, when the user's biometric information is stored to the SE **102** during setup, it is unable to be subsequently altered (e.g. data based on the user's fingerprint is stored on a write once memory and is unable to be modified or overwritten). In one embodiment, a registry maintains information about the status of registered SEs **102** and may be used during authentication to enhance security. For example, the registry may indicate whether a particular SE **102** is in good standing, has been reported stolen, etc., and the registry is used during authentication to determine whether a SE **102** is in good standing. Depending on the embodiment, the registration may be to a private registry (not shown), i.e., a registry established and maintained by a private entity such as an employer, individual retailer, healthcare facility, etc. and used by that entity, or a central registry **1304**, i.e., a highly-secured, centrally-located database administered by a trusted third-party organization.

The data stored by the registry may vary depending on the embodiment. In some embodiments, a registry includes a record in a database indicating that the SE **102** has been setup and registered. In some embodiment, a central register minimally includes a record for each registered SE **102**, and the record indicates that the SE **102** was setup and registered by a third-party trusted authority (e.g. in the presence of/witnessed by a notary agent). Certain transactions may utilize a central registry to authenticate an SE **102** using the central registry, i.e., determine whether a SE **102** taking part in the transaction has been setup and registered by a third-party trusted authority and may choose to deny a transaction if the SE **102** has not been setup and registered with the central registry.

In one embodiment, the registry does not store any user identifying or user associated data. For example, in one embodiment, the registry stores the record including an identifier of the SE **102** and a status of the SE **102**, but does not store a name or any other data associated with the owner of the SE **102**. In one embodiment, a registry may store information in addition to the record. In one embodiment, the registry may store user identifying data or user associated data. For example, in one embodiment, a registry may store biometric information of the SE's owner. In one embodiment, when a registry stores biometric information of the SE's owner such as a fingerprint, the fingerprint is encrypted using an encryption key held by the SE **102**. Such an embodiment may ensure that even if security of the central registry was compromised a user's biometric information could not be recreated. In one embodiment, the user's biometric information is created using a one-way hash so that the users biometric (e.g. fingerprint) cannot be recreated from biometric information even if unencrypted.

The backup server **1306** allows a SE **102**'s owner to backup his/her SE **102**'s data to the cloud where it is stored as user backup data **1308**. Should a user choose to backup his/her SE **102**, the backup server **1306** allows a user to select to backup the SE **102**'s data to the cloud, which may be beneficial should the SE **102** ever need to be replaced because of loss, damage, etc. In some embodiments, the backup server **1306** may perform a period backup automatically.

The tracking server **1310** allows an authorized user to track the movement of a SE **102** and determine the location of an SE **102**. For example, a user's employer may be authorized (e.g. by the user) to track the movement of the user's SE **102** during work hours in order to perform motion studies in the employer's facilities. In another example, the owner of the SE **102** may use the tracking server **1310** to perform a location query to locate his/her misplaced SE **102**.

The alert server **1314** allows users to define and store one or more alert conditions **1316** associated with a SE **102**. For example, an alert condition defined to send an SMS text message to an Alzheimer's patient's primary caretaker when the SE **102** of that patient enters or leaves a specified location or has not moved for a specified period of time.

FIG. **14** is a flowchart of a method **1400** for authentication using a secure element according to one embodiment. In the illustrated embodiment, the authentication is performed to determine whether to allow or deny an action in the system **100**. In the illustrated embodiment, the method **1400** begins at block **1402**. At block **1402**, the identification module **904** of a first SE **102** performs authentication to determine whether another SE **102** (e.g. a GSE at a point of sale) or host device **120** is valid. When the identification module **904** of the first SE **102** determines that the another SE **102** is valid (**1402**—Yes), the identification module **904** authenticates, at block **1404**, the user of the first SE **102** (e.g. performs biometric authentication of the user). When the identification module **904** of the first SE **102** determines that the user is the owner or authorized user of the first SE **102** (**1404**—Yes), an application on the host device **120** authenticates the first SE **102** and/or the identification module **904** of the first SE authenticates an application requesting the action at block **1406**. When the identification module **904** of the first SE **102** successfully authenticates the application and/or the application authenticates the first SE **102** (**1406**—Yes), a registry authenticates the first SE **102** at block **1410**. When the registry successfully authenticates the first SE **102** (**1408**—Yes), a registry authenticates the first SE **102** at block **1408**. The first SE **102** is in good standing (e.g. not lost, stolen, black listed, etc.) and the requested action is allowed at block **1410**. Should there be a failure of device authentication (**1402**—No), user authentication (**1404**—No), application authentication (**1406**—No) or registry authentication (**1408**—No), the action is denied at block **1412** according to the embodiment.

FIG. **15** is a flowchart of a method **1500** for a biometrically triggered transaction according to one embodiment. The method begins at block **1502**. At block **1502**, an SE **102** detects another SE **102** in range. At block **1504**, the SE **102** receives and buffers a biometric sample with an identifier of the other SE **102** that sent the biometric sample. At block **1506**, the SE **102** receives biometric information. At block **1508**, identification module **904** compares the biometric information to the biometric samples buffered on the SE **102**. When biometric information matches (**1510**—Yes) the local biometric sample (i.e. the biometric sample of the SE **102** that received and buffered the biometric samples at block **1504**), at block **1516**, the identification module **904** of that SE **102** authenticates the biometric information received at block **1506** against the biometric information of the SE's **102** owner and, at block **1514**, the wallet module **908** completes a transaction responsive to successful authentication at block **1516**. When biometric information does not match (**1510**—No) the local biometric sample, at block **1512**, the biometric information received at block **1506** is sent to an SE **102** device having the identifier associated with the matching biometric sample for authentication by that SE's **102** identification module **904**, and responsive to successful authentication by that SE's **102** identification module **904**, the wallet module **908** of the authenticating SE **102** completes a transaction at block **1514**.

FIG. **16** is a flowchart of a method **1600** for hardware abstraction based on a secure element architecture according to one embodiment. The method **1600** begins at step **1602**. At step **1602**, a set of virtual resources are consistently presented on a SE **102**. At block **1604**, the SE **102** determines a secure element (SE) architecture. If the SE **102** determines that the SE architecture is not a proxy model architecture (**1604**—No), the method **1600** continues at block **1608**. If the SE **102** determines that the SE architecture is a proxy model architecture (**1604**—Yes), the method **1600** continues at block **1606**.

At block **1606**, the abstraction layer **220** of the SE **102** maps one or more of the set of consistent, virtual resources to a remote resource on a host device **120** before continuing to block **1608**. At block **1608**, the abstraction layer **220** of the SE **102** maps unmapped consistent, virtual resources to local resources on the SE **102**.

FIG. **17** is a flowchart of a method **1700** for a secure element acting as a wireless storage device according to one embodiment. The method **1700** begins at block **1702**. At block **1702**, one or more of an SE **102** and an associated host device **120** determines that the two devices **102**, **120** are proximate. At block **1704**, the SE **102** biometrically authenticates the user. At block **1706**, the host device **120** mounts at least a portion of SE **102**'s memory as a local storage device. At block **1708**, the host device **120** reads data from and/or writes data to the mounted portion of the SE's **102** memory as it would do with a local storage device attached to or included in the host device **120**. At block **1710**, a determination is made that the SE **102** and host device **120** are no longer proximate or a time-out has occurred (e.g. requiring the user to re-authenticate after a specified duration of time has elapsed in order to keep the portion of memory mounted). At block **1712**, the host device **120** dismounts the portion of the SE's **102** memory.

In the above description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the specification. It will be apparent, however, to one skilled in the art that the specification may be practiced without these specific details. In other instances, structures and devices are shown in block diagram form in order to avoid obscuring the description. For example, one embodiment is described above with reference to particular hardware. However, the specification applies to any type of portable computing device that can receive data and commands.

Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the specification. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment.

Some portions of the detailed descriptions that follow are presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

The specification also relates to an apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes, or it may comprise a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable storage medium, such as, but is not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or optical cards, or any type of media suitable for storing electronic instructions, each coupled to a computer system bus.

The specification can take the form of an entirely hardware embodiment, an entirely software embodiment or an embodiment containing both hardware and software elements. In a preferred embodiment, the specification is implemented in software, which includes but is not limited to firmware, resident software, microcode, etc.

Furthermore, the specification can take the form of a computer program product accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer readable medium can be any apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

The medium can be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk—read only memory (CD-ROM), compact disk—read/write (CD-R/W) and DVD.

A data processing system suitable for storing and/or executing program code will include at least one processor coupled directly or indirectly to memory elements through a system bus. The memory elements can include local memory employed during actual execution of the program code, bulk storage, and cache memories which provide temporary storage of at least some program code in order to reduce the number of times code must be retrieved from bulk storage during execution.

Input/output or I/O devices (including but not limited to keyboards, displays, pointing devices, etc.) can be coupled to the system either directly or through intervening I/O controllers.

Network adapters may also be coupled to the system to enable the data processing system to become coupled to other data processing systems or remote printers or storage devices through intervening private or public networks. Modems, cable modem and Ethernet cards are just a few of the currently available types of network adapters.

Finally, the algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the required method steps. The required structure for a variety of these systems will appear from the description below. In addition, the specification is not described with reference to a particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the specification as described herein.

The foregoing description of the embodiments of the specification has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the specification to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the disclosure be limited not by this detailed description, but rather by the claims of this application. As will be understood by those familiar with the art, the specification may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Likewise, the particular naming and division of the modules, routines, features, attributes, methodologies and other aspects are not mandatory or significant, and the mechanisms that implement the specification or its features may have different names, divisions and/or formats. Furthermore, as will be apparent to one of ordinary skill in the relevant art, the modules, routines, features, attributes, methodologies and other aspects of the specification can be implemented as software, hardware, firmware or any combination of the three. Also, wherever a component, an example of which is a module, of the specification is implemented as software, the component can be implemented as a standalone program, as part of a larger program, as a plurality of separate programs, as a statically or dynamically linked library, as a kernel loadable module, as a device driver, and/or in every and any other way known now or in the future to those of ordinary skill in the art of computer programming. Additionally, the specification is in no way limited to implementation in any specific programming language, or for any specific operating system or environment. Accordingly, the disclosure is intended to be illustrative, but not limiting, of the scope of the specification, which is set forth in the following claims.

What is claimed is:

1. A system comprising:

a secure element configured to wirelessly communicate directly with an associated host device, the secure element including a memory storing data and a wireless storage module executable by a processor of the secure element; and

the associated host device including a link module executable by a processor, the link module of the associated host device cooperating with the wireless storage module of the secure element to wirelessly mount at least a portion of the memory as a storage drive of the associated host device.

2. The system of claim **1**, the system comprising:

a biometric sensor configured to obtain physical or behavioral characteristics from a user; and

an identification module executable by the processor of the secure element to authenticate the user as an owner of the secure element based on the obtained physical or behavioral characteristic.

3. The system of claim **2**, wherein one or more of the mounting of the portion of the memory and a user accessing the mounted portion of the memory is responsive successful authentication of the user as the owner of the secure element based on the obtained physical or behavioral characteristic.

4. The system of claim **2**, wherein the biometric sensor is included in the secure element.

5. The system of claim **2**, wherein the biometric sensor is included in the associated host device, but available to the secure element as a virtual biometric sensor via an abstraction layer.

6. The system of claim **1**, wherein the wirelessly mounted portion of the memory appears to the host device as a storage drive physically connected to the host device.

7. The system of claim **1**, wherein the mounting of the portion of the memory is based on one or more of a user configurable proximity and a user configurable duration of time for the secure element to be in proximity to the associated host device.

8. A method comprising:

presenting, to a secure element, one or more virtual resources; and

mapping the one or more virtual resources to one or more available physical resources based on a model architecture for the secure element and to provide hardware abstraction, the available physical resources varying based on the model architecture and an associated host device, the virtual resources allowing consistent interaction with the virtual resources regardless of variation in the physical resources available and their location.

9. The method of claim **8**, wherein the model architecture is a proxy model architecture, the method comprising:

mapping a first virtual resource to a first resource on the associated host device, and

wherein the mapping allows the secure element to interact with the first virtual resource as if the first virtual resource is a local resource of the secure element, wherein the secure element and the associated computing device are physically separate devices.

10. The method of claim **8**, wherein the model architecture is a proxy model architecture, the method comprising:

performing, at the secure element, a functionality of the secure element, the associated host device wirelessly controlling the performance of the functionality, the secure element performing the functionality on behalf of the associated host device, wherein the associated host device is physically separate from the secure element.

11. The method of claim **10**, wherein the functionality of the secure element performed is one or more of an authentication and the execution of a financial transaction.

12. The method of claim **8**, further comprising:

determining whether the security element is in proximity to the associated host device; and

responsive to determining the secure element is in proximity to the associated host device, permitting access to the associated host device.

13. The method of claim **12**, wherein the secure element may associated with one or more additional host devices and permit access to the one or more additional host devices when in proximity to the one or more additional host devices.

14. The method of claim **8**, further comprising:

determining whether the security element is in proximity to the associated host device; and

responsive to determining the secure element is in proximity to the associated host device, wirelessly mounting at least a portion of a memory of the secure element on the associated host device, the mounted portion of the memory appearing as a physically connected storage device at the associated host device.

15. The method of claim **14**, wherein the secure element may associated with one or more additional host devices and mounts the portion of the memory to the one or more additional host devices when in proximity to the one or more additional host devices.

16. The method of claim **8**, wherein the model architecture is a stand-alone model architecture, and the one or more virtual resources are mapped to physical resources available on the secure element.

17. The method of claim **8**, wherein the model architecture is a virtual model architecture, and the one or more virtual resources are mapped to physical resources available on the host device, wherein the secure element is a virtual secure element operating on the associated host device, but appearing to other devices as a separate device.

18. The method of claim **8**, wherein the secure element is platform agnostic and operates the same regardless of a platform the associated host device is operating.

19. The method of claim **8**, wherein the secure element is a single device that performs functionality of a thumb drive, a physical key, a logical key, a proximity based lock and performs user authentication.

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